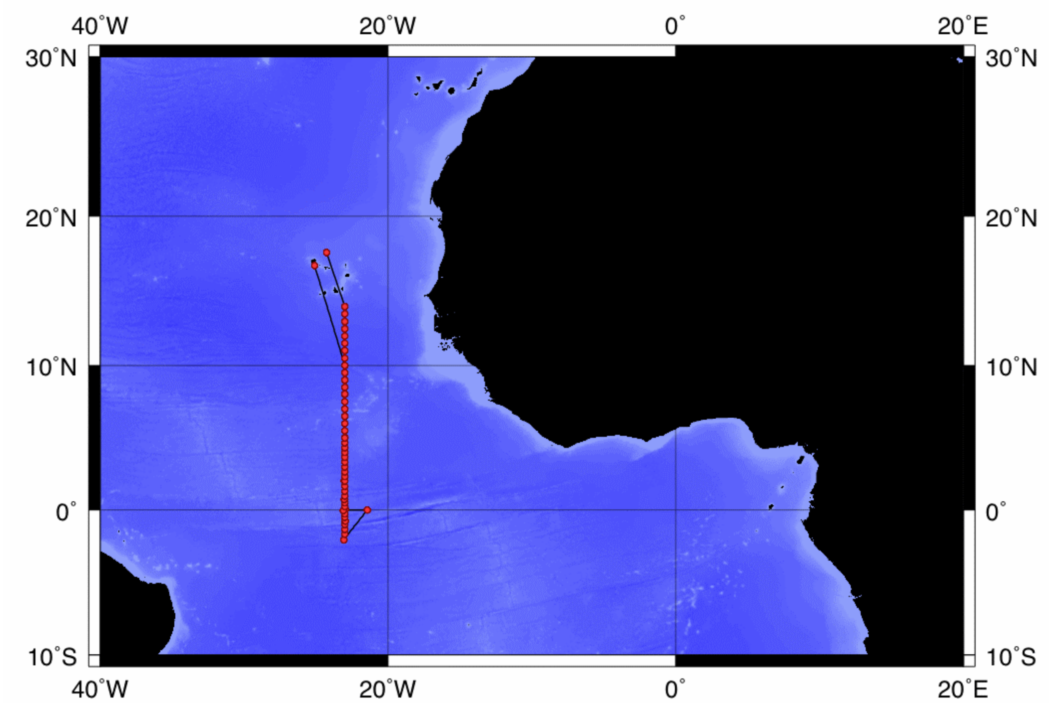
CRUISE REPORT A16C

(Updated May 2012)



Highlights

Cruise Summary Information

WOCE Section Designation	**A16C**
Expedition designation (ExpoCodes)	**35A320080223**
Chief Scientists	**Dr. Peter Brandt/IFM-GEOMAR**
Dates	Sat Feb 23, 2008 - Sat Mar 15, 2008
Ship	*L'ATALANTE*
Ports of call	Mindelo, Cape Verde
Geographic Boundaries	17° 35' N 25° 6' W 21. 36' W 2° 3' S
Stations	51
Floats and drifters deployed	0
Moorings deployed or recovered	8 mooring deployments 5 mooring recoveries

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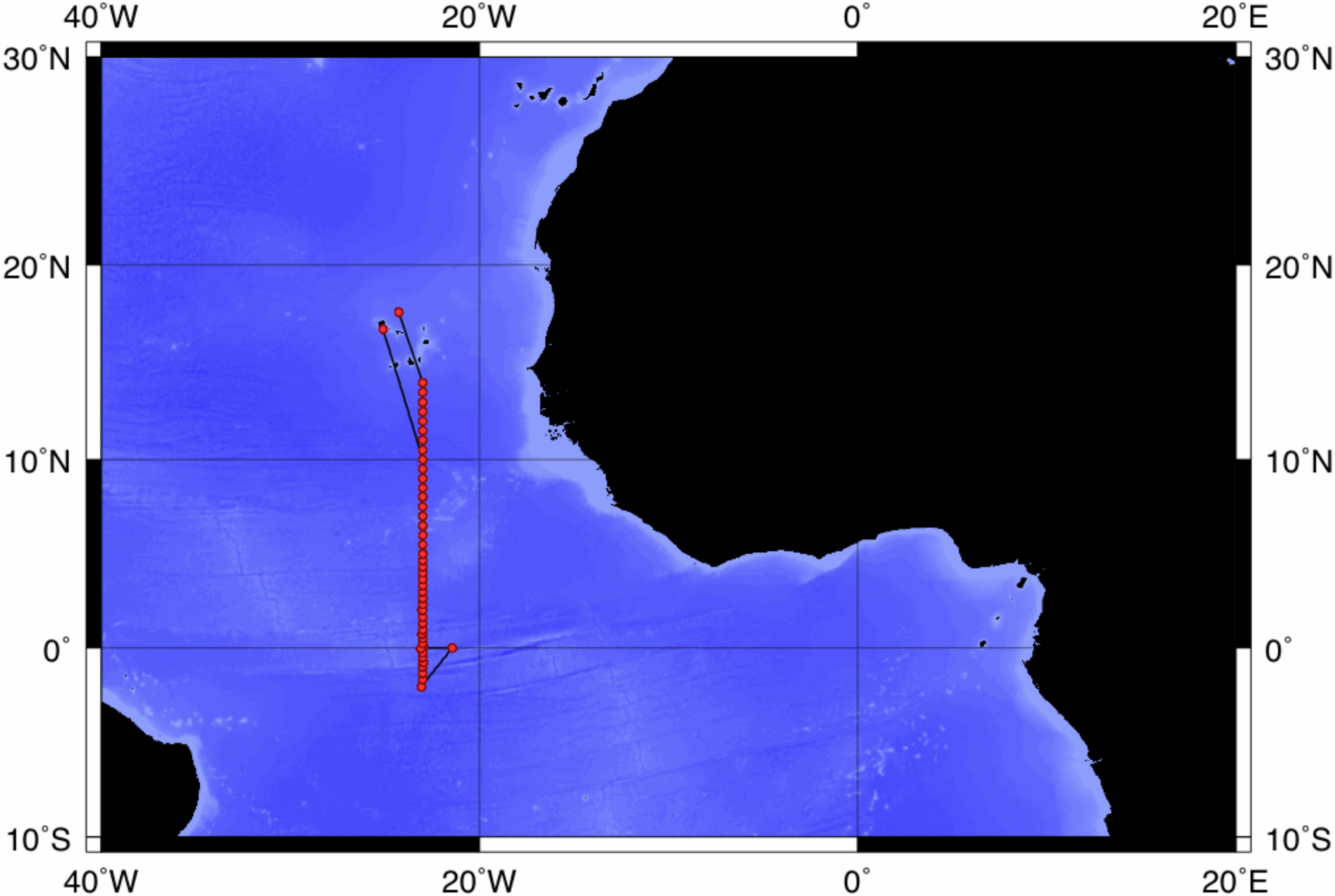
Links To Select Topics

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

A16C Brandt/IFM–GEOMAR (L'ATALANTE 2008) – 35A320080223



IFM-GEOMAR REPORT

IFM-GEOMAR

Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

R/V L'ATALANTE
Fahrtbericht / Cruise Report
IFM-GEOMAR-4

Circulation and Oxygen Distribution in the Tropical Atlantic

Mindelo/Cape Verde - Mindelo/Cape Verde
23.02. - 15. 03.2008

Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

Nr. 19
August 2008

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4.2 Research Program

The research cruise IFM-GEOMAR leg 4 aboard R/V L'ATALANTE is the first cruise of the new Sonderforschungsbereich 754 "Climate-Biogeochemistry Interactions in the Tropical Ocean". Shipboard, glider and moored observations are used to study the temporal and spatial variability within the oxygen minimum zone (OMZ) of the Tropical North Atlantic. This OMZ is located south of the Cape Verde islands and is generated by particularly low ventilation in addition to oxygen consumption due to heterotrophic respiration. At the same time, cruise IFM-GEOMAR-4 represents the main part of the BMBF program "Nordatlantik", subproject "Role of the equatorial Atlantic Ocean for climate variability in the Atlantic sector". Here, the equatorial current system, particularly the Equatorial Undercurrent (EUC), is the focal point of our research. Oceanic Mixing processes were studied in the frame of the DFG Emmy Noether project "Diapycnal mixing processes in the upwelling regions of the tropical Atlantic" as well as in the frame of the BMBF program "SOPRAN", subproject "The role of mixing and transport for the production and sea-to-air flux of N_2O and CH_4".

The research cruise included hydrographic station observations using a CTD/O_2 rosette, including water sampling for helium, oxygen and nutrients. Of particular importance were underway current measurements with both shipboard ADCPs (Narrow Band 75 kHz and 300 kHz). Diapycnal mixing processes were measured on station using a loosely tethered, free-falling microstructure probe. During IFM-GEOMAR-4, an intensive mooring program was carried out with 5 mooring recoveries and 8 mooring deployments. As part of BMBF "Nordatlantik", a mooring array consisting of 5 current meter moorings was installed along 23°W between 2°S and 2°N. This array is aimed at quantifying the variability of the thermocline water supply toward the equatorial cold tongue which develops east of 10°W during boreal summer. Within the framework of SFB 754, two moorings with CTD/O_2 profilers were deployed in the center and at the southern rim of the OMZ of the Tropical North Atlantic. The final mooring of IFM-GEOMAR-4 was deployed near the Cape Verde islands shortly before arrival at the port of Mindelo. During the cruise, one glider was recovered and another glider was deployed near the equator. Both gliders are equipped with CTD/O_2, chlorophyll and turbidity sensors.

4.3 Narrative of the Cruise

R/V L'ATALANTE departed from Mindelo on February 23, 2008 at 10:30L and headed south between the Cape Verdian islands of São Vicente and Santo Antão. South of São Vicente the scientific work commenced with the first CTD/O_2 station. Two gliders had been deployed at this location prior to the cruise and the CTD/O_2 data were needed for calibrating the CTD/O_2 sensors of both gliders. The first glider had been deployed on January 12, 2008 and travelled first along a southeastward track until 14°N, 23°W and then headed further south along the 23°W section. The second glider was deployed a few days before the cruise for a three day test mission. This glider was then loaded aboard R/V L'ATALANTE to be deployed later during the cruise. During the first CTD/O_2 station, several microcats and one newly developed oxygen logger were attached to the rosette. All instruments worked well and thus allow a proper pre-deployment instrument calibration. During the following day the working deck as well the instruments were prepared for the intense mooring work that will follow within the upcoming week.

On February 25, 2008, after another CTD/O_2 station to calibrate the glider sensor, the first glider mentioned above was recovered without any problems. Using the iridium telephone connection from Kiel/Germany, the dive depth of the glider had been reduced to only 100m, enabling the glider to surface more frequently (about once every 40 minutes). When R/V L'ATALANTE approached the position of the last surfacing, contact with the freewave radio transmitter/receiver system was readily established at a distance of 2-3nm. Over this radio contact the glider transmitted its precise position, and commands were given to keep it at the surface until recovery. Its recovery with the zodiac was a fast operation without any problems despite 2-3 m surface waves. This glider had finished a 45 day mission covering a distance of more than 1200km. All sensors, including temperature, conductivity, pressure, oxygen, turbidity and chlorophyll worked well from beginning to end. Barely any bio-fouling was found on the glider with only some corrosion at the connection between fin-tail and fin.

Following the glider recovery, R/V L'ATALANTE steamed toward the first mooring position at 8°N, 23°W. After a CTD/O_2 station during the night, the microstructure program commenced with the first 6 casts in the early morning on February 26, 2008. During these measurements, carried out at the portside of the aft deck, R/V L'ATALANTE steamed with 0.5 kn through water during probe deployment while increasing its speed to about 1 kn during descent and recovery of the probe. At 05:00L the microstructure measurements ended and a drift test started with R/V L'ATALANTE steaming with 1.5 kn through water against weak north-easterly winds at almost zero currents. In the mean time, sound speed data from the CTD/O_2 station at the planned mooring position was delivered to the multi-beam echo sounder aboard R/V L'ATALANTE to obtain reliably depth measurements. The survey of the bottom topography revealed a depth of about 4800m at the planned mooring position, with a variation of only a few meters nearby. The mooring deployments started at 06:40L on February 26. The ship moved slowly along the planned track, and after about 3h, all instruments including a McLane moored profiler with an oxygen optode had been launched into the water from the aft deck. A short steam of about 10min was needed to reach the anchor drop position, and the final mooring position was determined as 8°01.0'N, 22°59.0'W.

The mooring work at 5°N, 23°W started early in the morning on February 27. Communication with the releases was established using the hydrophone board unit of R/V L'ATALANTE, and the release command was sent at 06:30 L. The top element of the mooring surfaced within a few minutes, and the zodiac was used to connect it to the ship's A-frame. We noticed numerous scuff marks and cuts to the plastic jacket of the mooring wire during the recovery process. The moored profiler sitting near the lower stopper was entangled in a major and tightly pulled cluster of longline fishing gear, preventing the profiler from climbing the mooring wire as planned. In fact, a first glance at the recorded data showed that the profiler recorded full up and down cycles in all variables for the first 1.5 months only, and a complete failure of the vertical profiles afterwards. Both the Aanderaa current meter below the moored profile and the Microcats above and below the moored profiler indicate an occasional and sudden "dive" of the instruments of up to 300 m, consistent with being caught up in longline fishing activities.

The next mooring deployment started with a drift test at 12:00L. The ship arrived at the calculated start position at 13:30L, and the top element went into the water, followed by the remaining instruments in short order - a smooth operation without any problems. The anchor was dropped at the exact position, with the final mooring position being the same as the previous one, i.e. 5°00.9'N, 23°00'W. The submergence of the top element was observed, and R/V L'ATALANTE headed toward the next mooring position at 2°N, 23°W. This mooring is part of the equatorial array between 2°S and 2°N. After a deep CTD station and a drift test, the top element including a narrow-band ADCP was deployed at 16:20L. At about 19:55L the anchor was dropped exactly at the planned position, and the final mooring position is 2°02.5'N, 23°02.0'W. Due to darkness, the submergence of the top element could not be observed. Following the mooring deployment, the ship steamed 75nm to the next mooring position 0°45'N, 22°59.5'W. During the night, a shallow CTD station down to 1300m was taken, and upon sunrise on February 29 at 6:20L, the mooring was released, and was completely recovered at 10:40L. R/V L'ATALANTE headed toward the PIRATA buoy at the equator, 23°W. This position was chosen as the start position for a new glider mission using the glider ("Deepy") that was deployed a few days before the cruise for a test mission south of São Vicente. At 15:00L, the glider went into the water from aboard the zodiac. It was sent first for a 100m test dive. At 15:50L, it was back at the surface, and after checking its engineering and scientific data it was sent for another 800m test dive. It surfaced at 19:30L and we decided to send the glider on its northward path. Its last position at the surface was at 0°01.273N, 22°58.648'W. The plan is to recover the glider during a cruise aboard Maria S. Merian in April 2008 at about 8°N, 23°W.

A series of CTD and microstructure measurements was carried out during the night. The knowledge of captain and officers of R/V L'ATALANTE in handling the ship's drift during microstructure measurements was very helpful and considerably improved the quality of the obtained data, enabling the profiler to reach greater depths without distortion due the tension on the cable. As during the previous day, we released the mooring at the nominal position of 0°00'N, 23°06.8'W at sunrise, and the top element, including the PIRATA workhorse ADCP, was aboard R/V L'ATALANTE at 7:50L. During recovery of the moored profiler wire section, we discovered severe and repeated abrasions throughout the wire length. We decided to use the zodiac to pick up the moored profiler located at its upper stopper during the start of the mooring recovery and slowly moving along the wire while the mooring wire was spooled on the winch. The operation was successful and the remainder of the Benthos floatation elements and the releases were finally recovered at 11:00L. A first check of the moored profiler data showed that the profiler measured within the planned depth range during the first 4 months of the deployment only, with a subsequent continuous decrease of the maximum depth reached during descents.

During our previous mooring deployment at the equator 23°W in June 2006, we had headed into the southeasterly winds, where the mooring wire shifted from its straight position behind the ship and angled strongly toward the port side of the ship, resulting in severe tension on the mooring wire. We believe that parts of the mooring dropped into the depth range of the very strong EUC and were advected eastward. The current deployment did not feature any long mooring segment without buoyancy, and the problem should be significantly reduced. However, we decided to deploy the mooring headed downwind of the southeasterly wind (instead into it as usually). At the beginning of the deployment, we needed to increase the ship's speed to about 2kn (instead of 1.5kn usually used) to bring about enough tension to pay out the wire. The wire moved slightly to the starboard side during the entire deployment, with only some minor correction of the ship's heading required. The anchor was dropped at the exact position, and the final mooring position is again 0°00'N, 23°06.8'W.

Recovery of our equatorial mooring at 21°30'W was planned for March 1. We were not sure if this mooring was still at its deployment location since, starting on July 10, 2007, we had received ARGOS messages from the transmitter attached to the top element. However, both releases responded to the signal from the board unit and the mooring was released. The first element discovered at the surface was the 45'' flotation with the Longranger ADCP included. After the complete recovery, we had suffered only the loss of the top floatation with the ARGOS transmitter and a temperature/pressure logger. The three Microcats nominally located below the top element dropped down and recorded at unintended depth levels without creating any problems for the Longranger ADCP measurements.

On March 3, we started with the CTD section along 23°W at 2°S. Along the northward cruise track toward Cape Verde, CTD stations will be spaced 15' – 30' of latitude apart, somewhat closer near the equator. Water samples will be taken using the water bottles of the CTD/O_2 rosette. During most of the stations, water samples will be analyzed with respect to their contents of helium and nutrients (nitrate, nitrite, phosphate, and silicate) as well as salinity and oxygen to calibrate the sensors of the CTD/O_2 probe. Helium samples are typically taken in the upper 150m mainly in the equatorial region, while nutrient samples are measured in the upper 1000m along the whole section. Along our northward track, the program still allowed for some mooring deployments and recoveries. In the early morning of March 3, we deployed the southernmost mooring of our equatorial current meter array. As the topography appeared to be very rough, the deployment area was surveyed in detail with the multi-beam echo sounder, and a small area of about 1 by 1 nm was found featuring rather smooth topography at a depth of 4840m in between topographic ridges reaching up to 4350m. The mooring went out without problems, and submergence of the top element was observed after the anchor was dropped. The final mooring position is 1°56.4'S and 22°57'W, exactly at the planned position. During the afternoon and the following night, 3 CTD profiles down to 1300m were taken. Early in the morning of March 4, we recovered the last of our moorings deployed in June/July 2006 during M68/2. Both releases responded and the mooring was recovered completely without problems. In summary, we were able to recover all instruments of all moorings except for the top floatation of the equatorial mooring at 21°30'W that was severed on July 10, 2007 as well as one single temperature/pressure logger.

After a CTD station and microstructure measurements, the continuation mooring was deployed at the same position without problems and the final mooring position was calculated, using the positions of the anchor drop and the submerging of the top element, to be 0°44.95'S, 22°59.70'W. During the night, the CTD section was continued toward the equator. In the equatorial mooring deployed 4 days earlier, we had incorporated an additional top element including a 1200 kHz ADCP with a release attached to the top of the remaining mooring. The ADCP was used to measure within the vertical shear zone between the eastward flowing EUC with a core depth at about 50m and the westward flow above. Before recovering the top element on March 5, its position was exactly triangulated and the position of the upper release was determined to be 0°00.22'N, 23°06.76'W at a depth of 177m. The 1200 kHz ADCP acquired good data with a vertical and temporal resolution of 50 cm and 2s, respectively, and a vertical range of about 20m showing vertical shears up to 0.07 s^{-1}. The variance of the velocity data will be analyzed in comparison to the microstructure measurements near the mooring to obtain further insight into the mixing processes in the shear zone above the EUC.

The last mooring deployment in the equatorial region started on March 6 at 6:00L. The mooring went into the water without problems. Before the anchor drop at 9:35L, the top element of the mooring was followed by the zodiac to film its submergence - a successful operation. In addition, the submergence position was located exactly, and the resulting mooring position is 0°45.17'N, 22°59.28'W.

During the following days, we continued the CTD/O_2 section along 23°W northward. South of 2°N and between 7°N and 9°N (the region of the tracer release experiment scheduled for April 2008), each CTD station was followed by a microstructure station consisting of 3 microstructure profiles. North of 9°N, R/V L'ATALANTE headed against quite strong northerly winds and its speed dropped to about 9 kn. To stay within the scheduled program, we decided to cancel further microstructure measurements south of the Cape Verde islands. The meridional section along 23°W was concluded on March 12 at 11:00 with the last CTD/O_2 station at 14°N.

Before deploying our last mooring north of São Vicente, we had to stop at the port of Mindelo to pick up an Inverted Echo Sounder to be installed near that mooring but was inadvertently left behind at INDP in Mindelo. Using the zodiac of R/V L'ATALANTE, the instrument, as well as the baggage of the crew member which had not arrived in time before the cruise, was brought onboard the vessel without much time delay. On March 13 at 18:00L, we arrived at the planned mooring position at 17°36'N, 24°15'W. During the night we conducted two three hour microstructure stations, separated by one deep CTD station down to the bottom. On March 14 at 4:00L we started the drift test for the mooring deployment, and at 6:00L the top element including a fluorometer, a microcat and an ARGOS watchdog, went into the water. The whole mooring deployment took about 4 hours, and the anchor was dropped at the planned position. Submergence of the top element was observed. Since more than one hour later no ARGOS signal had been received, we deemed the mooring successfully deployed. During lunchtime, microstructure measurements were carried out and at 14:00L, while preparing for the deployment of the Inverted Echo Sounder, we observed the top element of our mooring located right at the surface, at times flushed by the waves. It soon became clear that the top element was still attached to the mooring, but at least 40m shallower than expected. The only option without releasing the mooring again was to cut off the top element. In this case, 34m of mooring, with two microcats, attached would drop down below the next Benthos group. They would represent no harm for the remainder of the mooring as long as the new top element would stay deep enough below the surface. As there was the possibility that the top element would re-submerge due to changing currents, we quickly decided to use the zodiac to attach a rope via the ship's A-frame to the top element. In a perfectly executed operation, the captain drove the ship backward to stop exactly in front of the top element. At 16:15 L the top element was picked up and heaved out of the water using the ship's capstan. After a haul of only two to three meters, the tension on the mooring wire became very severe. The wire was cut below the top element. From the proximity of the cut position to the actual mooring position we assume that the mooring wire was almost completely stretched and that after cutting the top element, the next Benthos group is about 20m below the surface. The risk for rising to the surface during low current conditions is regarded to be small. As the water depth at the mooring position was exactly determined by independent measures from the CTD, the multi-beam echo sounder during the last R/V METEOR cruise as well as the triangulation of the releases and agreed with expected values of about 3600m, we believe that the only explanation for the surfacing of the top element is a mooring longer than planned. We must check with the manufacturer of the mooring wire if such a mistake is possible and can be prevented for any future deployments. The triangulated mooring position is 17°36.244'N, 24°14.915'W. Note that this location is closer to the anchor drop position than expected, with the backdrop of the anchor only about 9% of the total mooring length.

The inverted echo sounder was then deployed without problems at 17:10L near the mooring at 17°36.031'N, 24°14.604'W. During the night we continued with a 24 h microstructure station near the mooring position. The scientific work of R/V L'ATALANTE cruise IFM-GEOMAR leg 4 ended at 11:30L and the ship headed toward Mindelo where the cruise ended on March 15, 18:00L (Fig. 4.1).

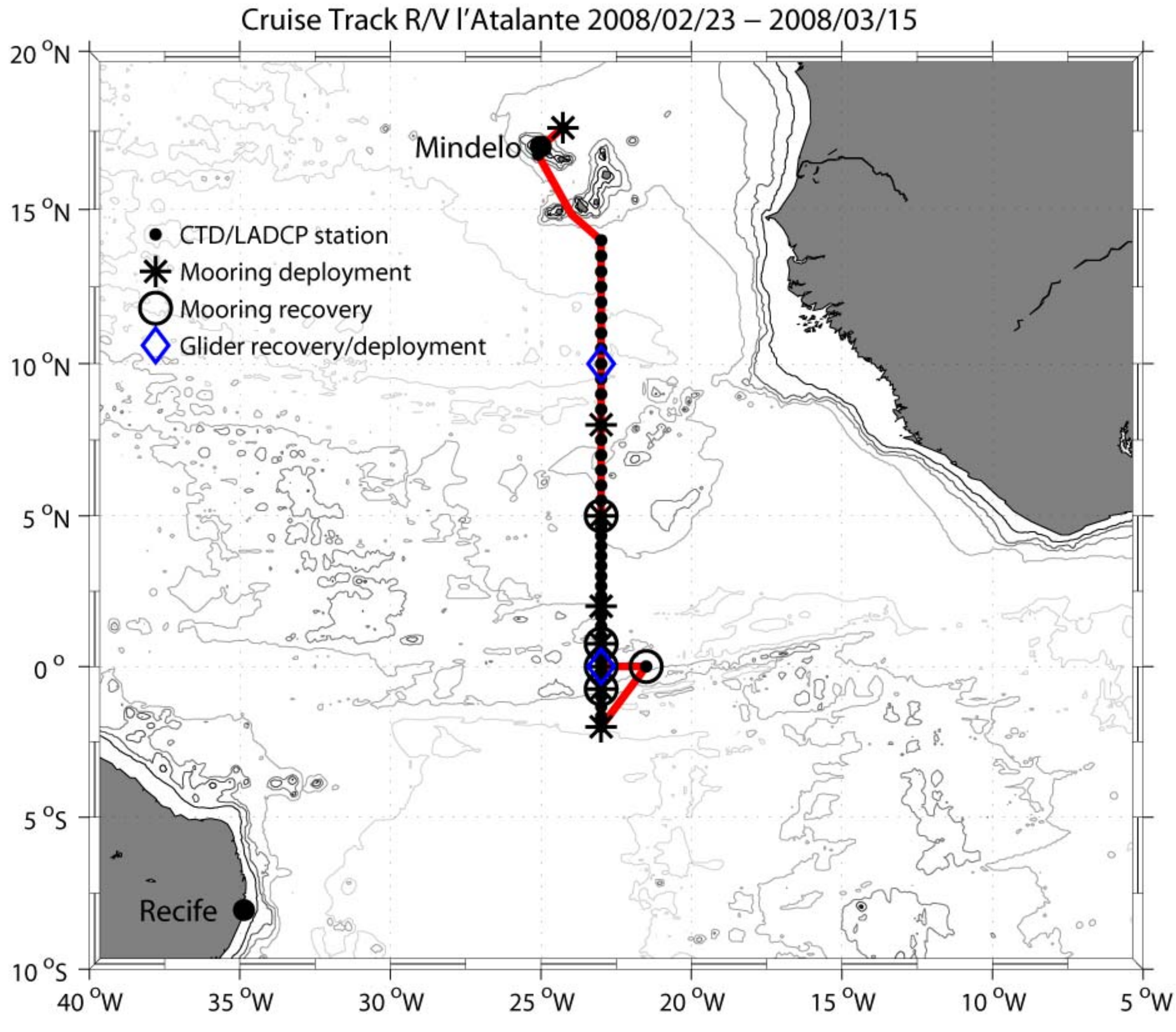


Fig. 4.1: Cruise track of R/V L'ATALANTE cruise IFM-GEOMAR leg 4.

4.4 Preliminary Results

4.4.1 CTD and Oxygen Measurements

4.4.1.1 Technical Aspects

During the whole cruise a Seabird SBE 9 system, the IFM-GEOMAR, Kiel SBE-5 S/N 0410 was used. The software used was the Seabird Seasave V7.12 program. For the final calibrated datasets the data from the primary set of sensors (temperature s/n 2120, conductivity s/n 1494, and oxygen s/n 0985) were used. During profile 5 the secondary set of sensors showed a problem with the oxygen sensor (s/n 1287), which could be resolved by changing the data transmission channels. A comparison with the Winkler titrated sample data showed that the problem had existed also during the first four casts and might have already been present during the previous leg. Although the second conductivity sensor (s/n 2512) showed slightly higher quality than the primary sensor, we decided to use the primary set of sensors as it worked continuously throughout the whole cruise. A comparison of the secondary temperature sensor (s/n 4547) showed that the two temperature sensors had a mean offset of 0.003°C with a standard deviation of 0.004°C. A second Seabird CTD, IFM-GEOMAR, Kiel SBE-4, was available as backup system, but was not used.

During the cruise a total of 51 CTD-profiles were performed. These were usually taken to 1300m depths, only at the mooring positions deep casts to the bottom were performed. For the deep CTD-casts the bottom was detected by an altimeter. This worked reliably and the CTD had no ground contact at all during the cruise. However, a reliable range was only available at distances closer than 30m to the bottom. Sound speed profiles derived from CTD data were used to correct the echo sounder of the ship and a comparison of CTD pressure/altimeter and echo sounder showed a good agreement.

The Seabird bottle release unit used with the rosette worked properly and reliably except for some cases, when niskins 3 or 4 did not close. During the first half of the cruise some leakages of the bottles occurred, an exchange of the nylon bands by steel spiral springs inside the bottles led to some improvement.

The salinity samples were analyzed with a Guildline Autosal salinometer (Kiel AS7).

The conductivity calibration was performed using a linear fit with respect to temperature. Tests with linear or quadratic fits in pressure or conductivity did not improve the quality of the fit in a significant manner. Using 66% of the 253 samples for calibration, an rms difference of 0.00025 S/m corresponding to a salinity of 0.0025 PSU was found for the upcast. We chose the downcast as final dataset for several reasons:1) Sensor hysteresis starts from a well defined point, 2) the incoming flow is not perturbed by turbulence generated by the CTD-rosette, and 3) long stops during the upcast profiles lead to unsteady profiles over depth. For the downcast conductivity, we got an rms difference of 0.00051 S/m corresponding to a salinity of 0.0052 PSU. A comparison with a different calibration including the outliers showed significantly larger rms differences but the final calibrated profiles were identical within about 0.001 PSU indicating that the restriction to the highest quality data does not introduce systematic shifts in the calibration results. A comparison of up- and downcast profiles shows that the intrinsic time and space variability are much larger than the uncertainties involved in the calibration processes.

For the oxygen calibration the oxygen content of the water samples has been determined by Winkler's titration method. The downcast has been calibrated using all samples within 2.8 standard deviations of the observed differences. This includes 613 of 694 data samples and led to an rms difference of 0.052 ml/l using a linear correction for temperature, pressure and oxygen itself.

4.4.1.2 Water Masses and Oxygen Distribution Along 23°W

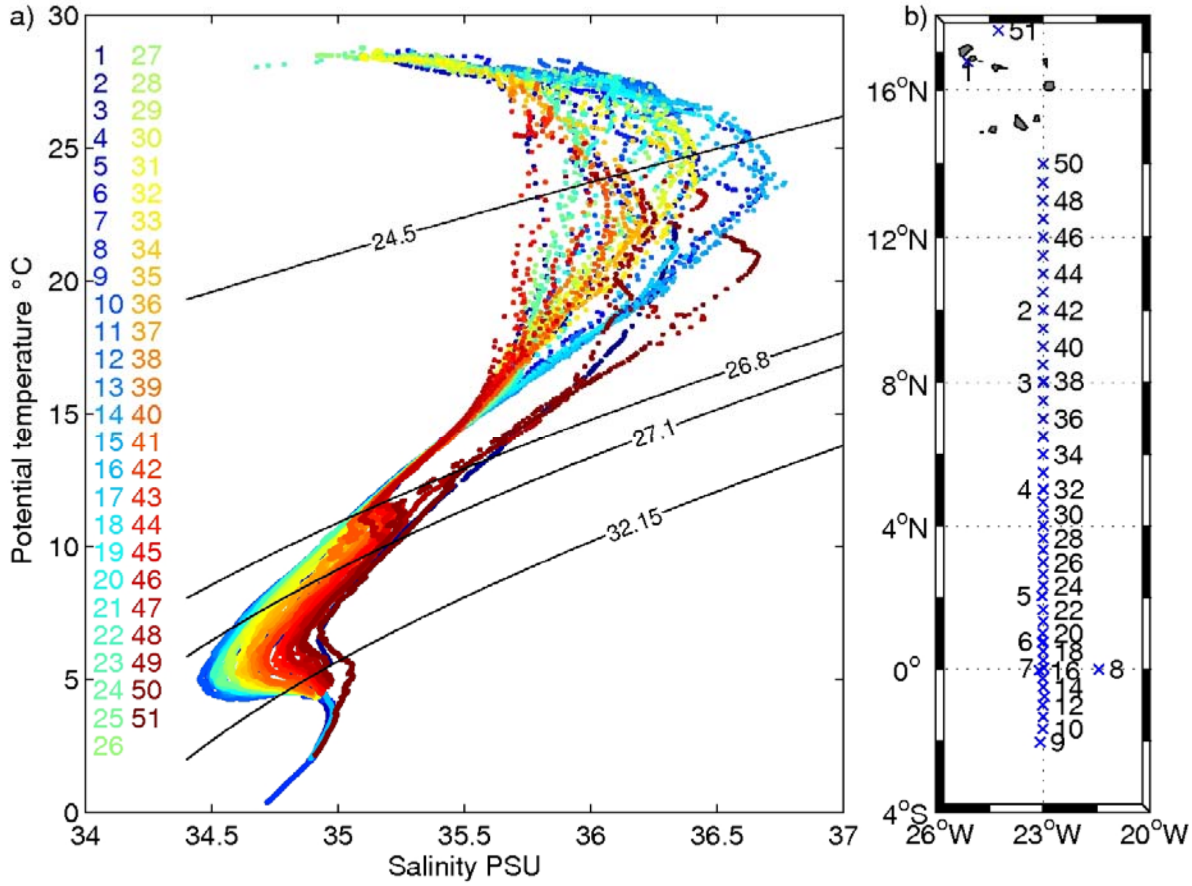


Fig. 4.2: a) θ-S diagram, the color code denotes the profile number. Later profiles are plotted on top of the earlier profiles. b) CTD station map.

During the cruise, the Cape Verde Frontal Zone was crossed twice and the shift from the more saline, higher temperature regime of the North Atlantic Central Water (NACW) to the fresher, lower temperature regime of the South Atlantic Central Water can easily be identified between Stations 1, 49, 50, 51 and the other stations south of about 13.25° N (Fig. 4.2). Below the Central Water layer, the AAIW can be identified by its salinity minimum and at the deep stations at the mooring positions also the saltier NADW is found underneath.

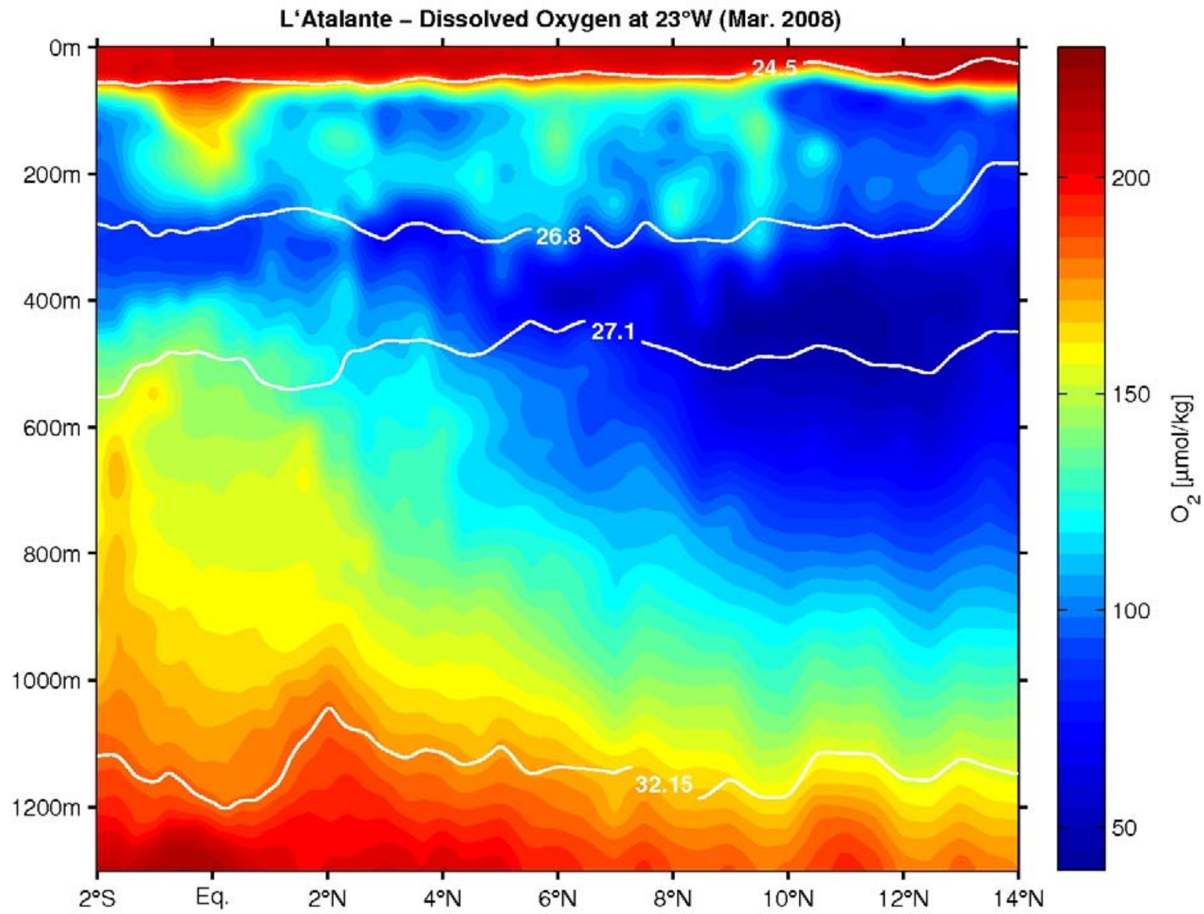


Fig. 4.3: Oxygen distribution along 23°W. White lines show isolines of σ_θ=24.5, σ_θ=26.8 σ_θ=27.1 and, σ_{1000}=32.15kg/m³.

During the cruise the oxygen minimum zone in the eastern tropical Atlantic is observed with lowest oxygen concentrations below 50 µmol/kg between 400 and 600 m water depth and at 9 to 12°N (Fig. 4.3). In the equatorial region high oxygen concentrations are observed in the regime of the Equatorial Undercurrent (EUC). The Northern and Southern Intermediate Counter-currents (NICC and SICC) also show high oxygen concentrations. An intermediate depth oxygen maximum at the equator at 350 m depth as observed during the R/V METEOR cruise 68/2 in June/July 2006 was not found during the R/V L'ATALANTE cruise.

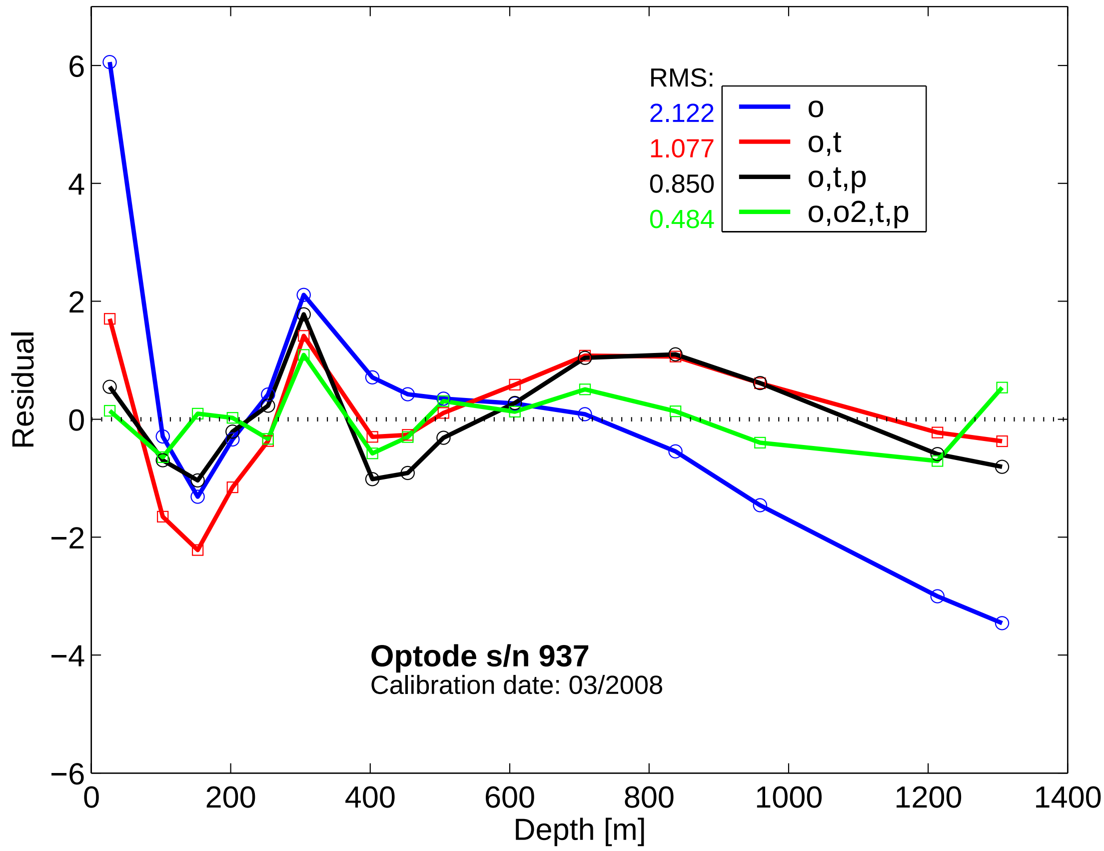
4.4.1.3 Oxygen Optode Calibration

The Physical Oceanography Department at IFM-GEOMAR in Kiel uses the Aanderaa Optode 3830 on various platforms, including moored fixed level instruments, moored profilers, and autonomous gliders. The instrument specifications claim longterm stability of measurements (more than one year) without recalibration. However, our comparisons with CTD measurements show that the factory settings require an instrument-specific calibration to satisfy our accuracy needs in order to measure oceanographically relevant signals. To perform the calibration measurements, the optode loggers were installed in our in-house built, self-recording loggers.

During Leg 4, we performed shipboard calibrations of various sensors for a pre or post-deployment check, essentially consisting of the following:

1) Oxygen loggers mounted on the CTD rosette and deployed during a regular CTD cast, typically to 1300 m during this cruise.
2) During the upcast, 12 bottle stops are taken of 2 minutes each to allow all sensors to "settle" and to take a water sample for subsequent oxygen determination via Winkler titration.
3) The raw CTD profiles undergo post-cruise calibrations using the water samples for salinity and oxygen (and other parameters, primarily nutrients and tracers). Optode calibrations utilize the calibrated CTD data.
4) Time series of temperature and oxygen for CTD and optode are compared via the minimum residual method to determine the time lag between the two respective instrument clocks. This time shift is typically a few seconds (5-10 sec).
5) The time periods for the 12 stops are determined from the pressure record of the CTD.
6) Based on these time periods, the bottle stop values for temperature and oxygen are averaged for CTD and optode, plus pressure and salinity averages for the CTD. These values are written a bottle stop file, also including the titrated bottle oxygen values.
7) Optode oxygen values are corrected for salinity and pressure effects, using the Aanderaa specified numbers in the routine 'o2corr'.
8) Multifit regressions are performed for a correlation between CTD oxygens and (corrected) optode oxygens, in the following configurations:
   a) Ox(ctd) vs. Ox(opt)
   b) Ox(ctd) vs. Ox(opt), temperature
   c) Ox(ctd) vs. Ox(opt), temperature, pressure
   d) Ox(ctd) vs. Ox(opt), Ox(opt)**2, temperature, pressure
9) The results demonstrate that only the fourth fit (8d), including a quadratic dependence on oxygen, consistently reduces the rms error, and also removes the pressure dependence of those residuals. Other combinations of fit parameters were tried and found to be equal or inferior to the above version 8d. An example plot of the residuals vs. depth for sensors s/n 937 and 946 is shown in Fig. 4.4.
10) Temperatures of the optode measurements were subjected to a linear fit vs. CTD temperatures.
11) The results of all fits for the various instruments are shown in Table A4.2.

Caution: Instrument s/n 943 and 839 (last 2 sets) were calibrated during R/V Merian cruise MSM08/1 in April 2008, using only 5 and 4 bottle stops, respectively. This small number of calibration points does not permit a 4^{th} order fit with adequate certainty. Use with caution!



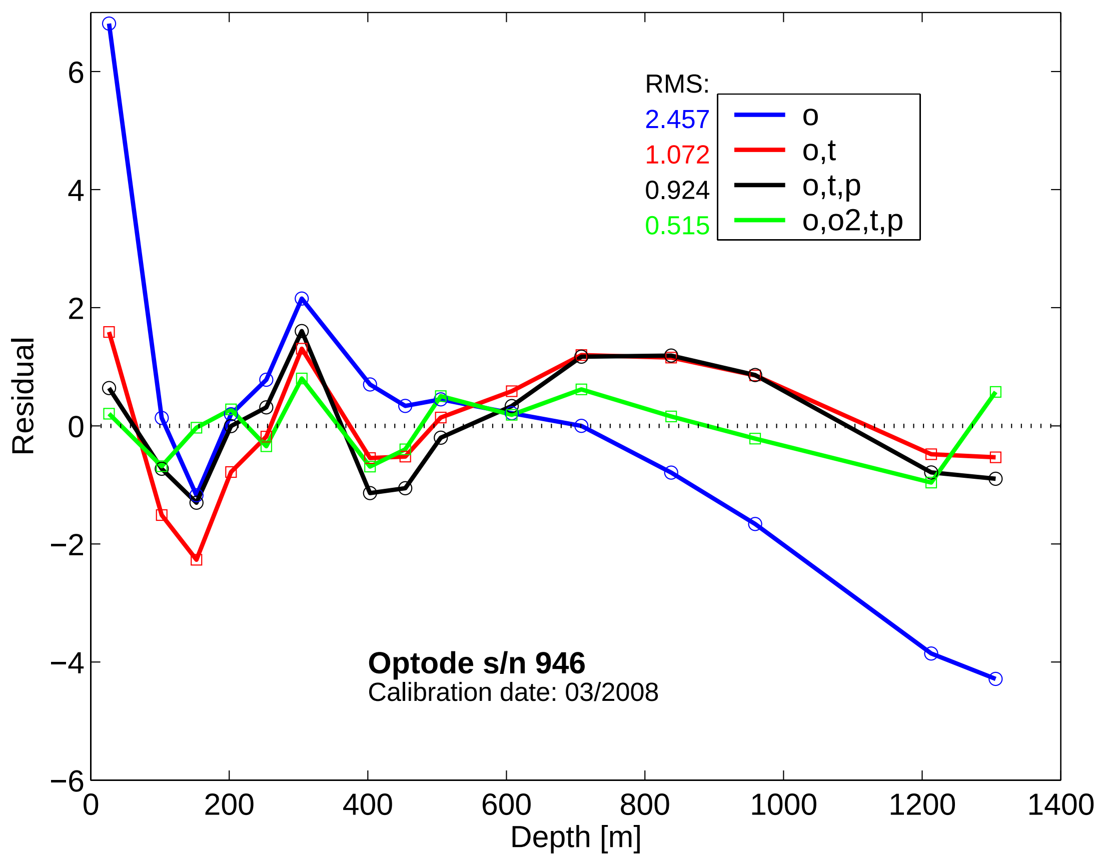


Fig. 4.4: Residuals of various parameter configuration fits for oxygen optodes s/n 937 and 946, respectively.

4.4.2 Current Observations

4.4.2.1 Vessel Mounted ADCP: Technical Aspects

RV L'ATALANTE holds two hull mounted RDI Acoustic Doppler Current Profilers with frequencies of 75 and 300 kHz. Both ADCPs are oriented approximately 45° relative to the ship's bow. The 300 kHz instrument interferes with the hull mounted Doppler Velocity Log (7 pings per second), but to a tolerable amount. Default sources of navigational information are an AQUARIUS GPS (2 antennae) for position and a calculated "hybrid" signal for heading, merged from the same AQUARIUS GPS with one of two OCTANS Fibre Optic Gyros. This hybrid-heading aims to meet the advantages of the GPS's long-term stability and the FOG's short-term accuracy and resolution. Its disadvantage is the undisclosed and thus irreversible algorithm to calculate hybrid-heading. The pure GPS heading signal generated by the AQUARIUS 2-antennae attitude array is available on request as ASCII-files at 10-second intervals. This heading source proves to be slightly less noisy than hybrid-heading.

Alternative but worse sources of navigational data are:

a) "integrated" position, calculated from different sources by an undisclosed algorithm, proves to be noisier than GPS position
b) pure FOG-heading, noisier than hybrid-heading because of drifting offset
c) so-called HDMS-heading, calculated from different sources, with huge excursions from true heading from time to time

During Leg 4 of R/V L'ATALANTE cruise 2008, both ADCPs worked continuously, in narrowband mode and at ping rates of 1 per second (300 kHz) and 1 per 2.4 seconds (75 kHz). The 75 kHz unit with 16-m-bins had a range of about 400 m while cruising and 500 to 600 m on station. The depth range of the 300 kHz unit was about 100 m at 4-m-bins, mainly depending on scatterer density. The system software TRANSECT delivered single ping data of beam velocities and backscatter amplitude as raw data files and NMEA strings of navigational data as ASCII navigation files. Calibration with GPS positions and GPS attitude array headings produced velocity data of good quality: 10-minute-average velocities showed a standard deviation of heading misalignment of 0.5 to 0.6°, and even 1-minute-average velocities still showed a standard deviation of 0.8 to 0.9° accompanied by an unusual smooth appearance of the processed velocity sections. This was partly due to a calm sea state during most of the cruise. Successful parameters for data processing were misalignment angles of -44.1° (300 kHz) and -45.2° (75 kHz) as well as amplitude factors of 0.997 (300 kHz) and 1.0 (75 kHz).

4.4.2.2 Lowered ADCPs

During the cruise two 300 kHz RDI Workhorse ADCPs were attached to the CTD rosette. With these two instruments full CTD depth current profiles could be obtained. The up-looking ADCP was serial number 7915, a loan from the University Bremen. The down-looking ADCP was serial number 690 of IFM-GEOMAR. The instrument from Bremen had been used since another instrument from IFM-GEOMAR had developed a bad beam during one of the preceding legs. Serial number 690 had since the start of leg 4 or earlier one weak beam. We found during all profiles that the instrument from Bremen had 20 m more range than the instrument from Kiel (typically 150 m compared to 130 m in shallow waters). Whether this was caused by the instrument being newer (guessed from the higher serial number) or whether there is a hardware or firmware difference, we do not know.

For CTD profile number 1, a glider calibration station near the Cape Verde Islands, the instruments could not be started. No lowered ADCP data was thus collected for this profile. During the following days it was discovered that the serial cable connection had gone bad near the plug to the battery pack. Water was found inside the cable (this cable never enters the water, so that the wetting must have occurred by rain or the hosing of the CTD with freshwater after a profile). The connection was resoldered and covered with a two-component plastic seal. As we on previous cruises had similar problems, as the number of wires coming out of the battery pack is not sufficient (we need 8 instead of the current 7 wires for 2 serial connections and the battery voltage), and as the battery pack itself had shown contact problems with the battery cells on a previous cruise, a proper refurbishment of the battery packs and the attached cables is due after the following cruise on FS Merian.

During this cruise we could for the first time use two newly acquired USB to Serial converters that use a signal voltage of 12V instead of the usual 5V for the serial lines. This indeed solved all the connection problems we had encountered on previous cruises. We were thus able to implement the parallel downloading routines from Andreas Thurnherr of Lamont-Doherty Earth Observatory. This cuts in two the time needed to download data from the ADCPs and also makes the switching of cables or instruments between downloads unnecessary. In all this setup worked extremely well during the cruise.

For all the following profiles, with the exception of profile 3, the lowered ADCP worked as intended. During profile 3 the up-looking ADCP did not record during the whole cast and produced 2 data files, an indication that it might have lost the connection to the battery during the profile. This did, however, not occur again and we were thus unable to solve whatever problem might have been the cause.

The data quality during all shallow profiles (most CTD profiles went only down to 1300 m) was very high. Parallel processing by Rebecca Hummels and Gerd Krahmann, one including shipboard ADCP data and one not, showed only minor differences, indicating that the quality of the lowered ADCP data is very high. For all deep profiles the quality degraded severely and while not totally unusable the velocity error on all deep profiles is rather high with up to 10 cm/s. For future cruises collecting deep lowered ADCP profiles one needs to investigate what the difference between the instruments from the University Bremen and the one from IFM-GEOMAR is and what the recent development of a higher powered 300 kHz workhorse by RDI has resulted in.

4.4.2.3 Selected Results

Fig. 4.5 is a composition of zonal velocity data from 300 kHz and 75 kHz 10-minute-averages and LADCP-data along 23°W. The most prominent feature is the eastward Equatorial Undercurrent (EUC), with its core at 50 to 70 m depth; underneath, the westward Equatorial Intermediate Current (EIC) is clearly observable. The Northern Intermediate Countercurrent (NICC) at 2°N and 400 m is shallower than usual. Instead of the lacking northern branch of the South Equatorial Current (nSEC), an eastward shallow current at 3°N is observed; a quite persistent one, which has been found in the Leg 2 data of January 2008, too. The North

Equatorial Countercurrent (NECC) is absent as expected, while an eastward structure at 9°N is present which may be interpreted as northern branch of the NECC.

Fig. 4.6 illustrates the good quality of the 300 kHz 1-minute-averages during the two equator crossings. The resolution of 4 m vertically, 300 m or less horizontally (depending on ship speed) and 1 minute in time allows resolving the current fine structure. Not only the undulations in the upper high-shear part of the EUC may be seen (spatial scale roughly 10 km, time scale roughly 20 min), but vertical excursions of the whole EUC of 20 to 30 m on timescales of a few days – Figs. 4.6a and 4.6b are sections separated by 2 to 6 days.

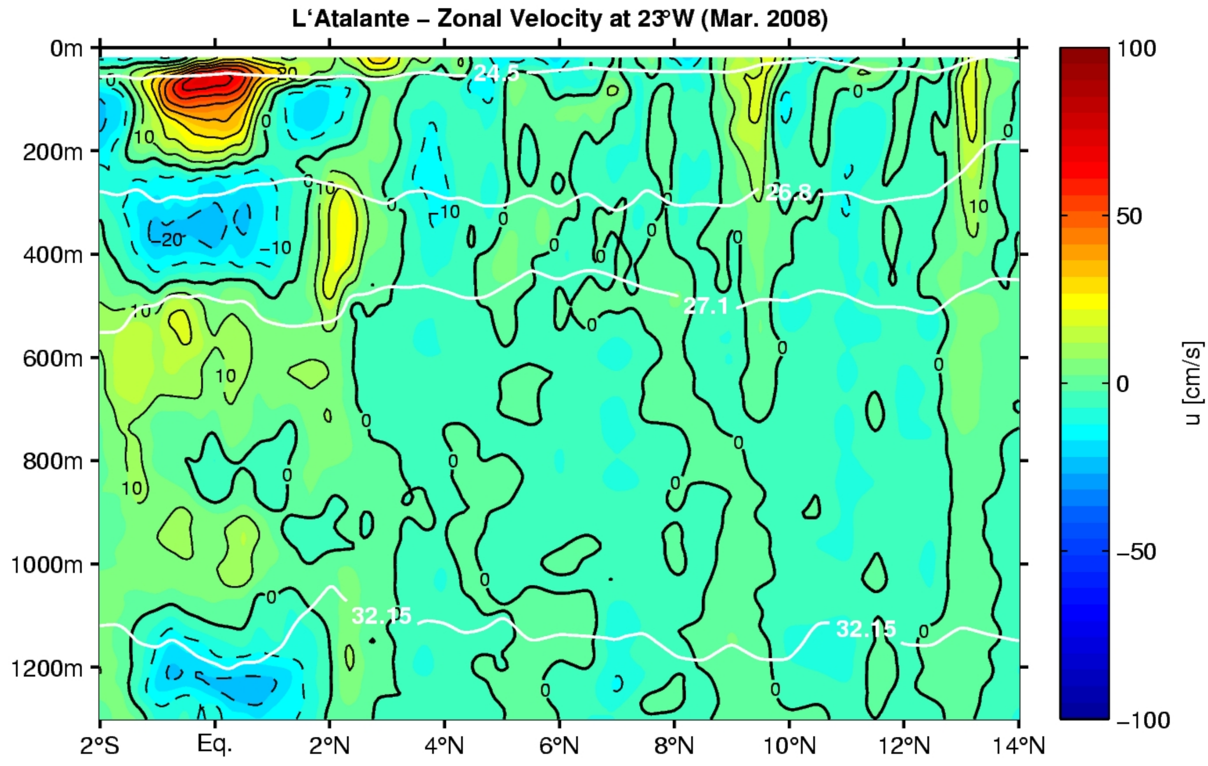


Fig. 4.5: Zonal velocity along 23°W. Composite section of vessel mounted ADCP (300 kHz, 75 kHz) and LADCP measurements. White lines show isolines of σ_θ=24.5, σ_θ=26.8 σ_θ=27.1 and, σ_{1000}=32.15kg/m³.

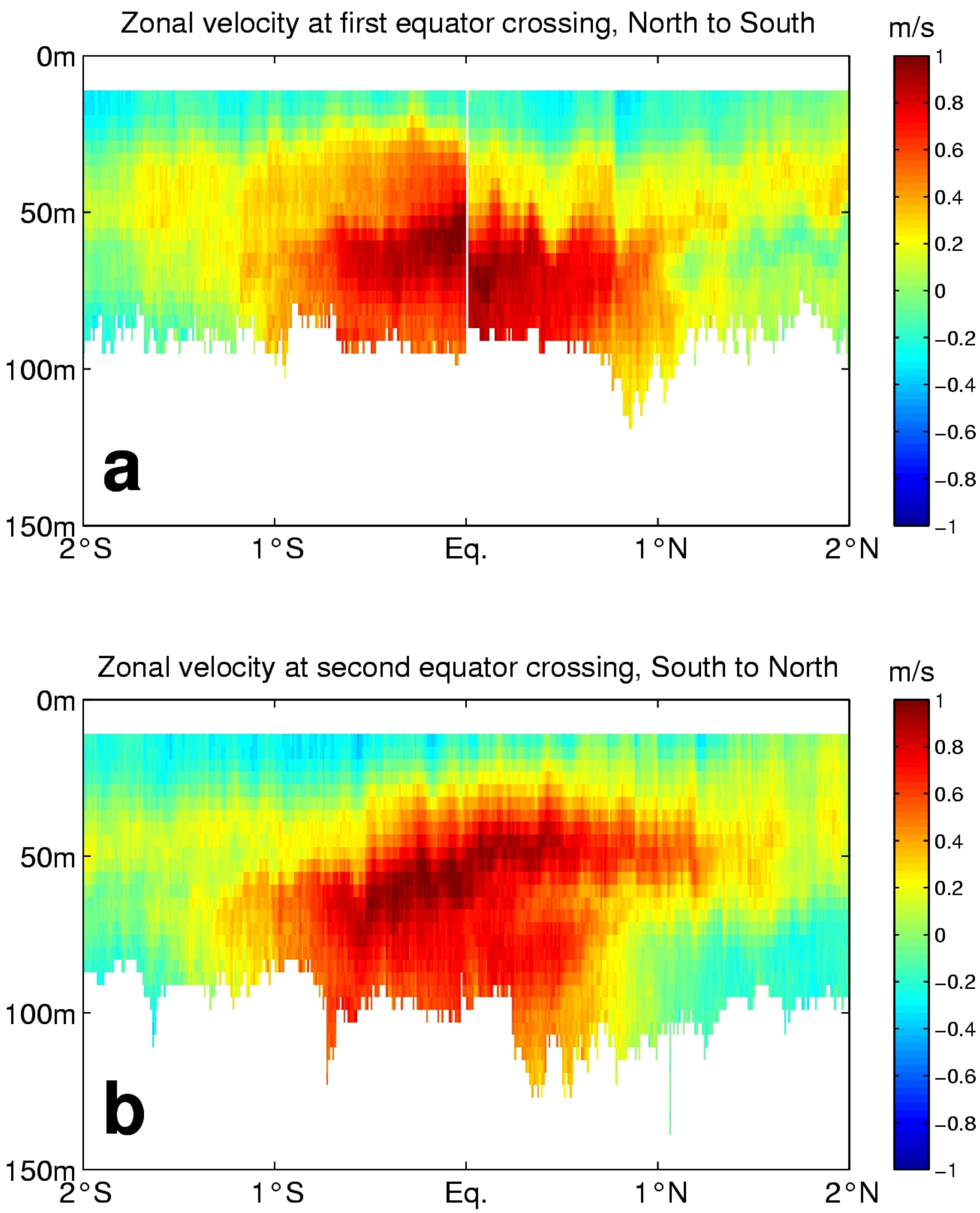


Fig. 4.6: Zonal velocity from 300 kHz vessel mounted ADCP during two crossings of the equator. a) Northern branch: 28.02.2008, 12 a.m. to 29.02.2008, 6 p.m. from north to south at 23°W. Gap at the equator is 29.02.2008, 6 p.m. to 02.03.2008, 10 a.m. while going along the equator from 23°W to 21.5°W. Southern branch: 02.03.2008, 10 a.m. to 03.03.2008, 3 a.m. from north to south, starting at 21.5°W and ending at 23°W. Visible inhomogeneity at 0.75°N is caused by long stay due to mooring activities. b) 03.03.2008, 6.a.m. to 07.03.2008, 10 a.m. from south to north at 23°W.

4.4.3 Mooring Operations

The mooring activities of R/V L'ATALANTE cruise IFM-GEOMAR - 4 served two major scientific programs, the BMBF-funded 'North Atlantic' project with a focus on the equatorial circulation, and a newly installed SFB focused on oxygen minimum zones (OMZs). The plans called for recovery of 6 moorings and deployment of 8 moorings. Fortunately, the ship was able to recover the TENATSO mooring V440 (also known as KPO_1006) during the previous leg en route to the port of Mindelo. However, several of the near surface instruments were exposed to major biofouling (barnacles, mussels, etc.), causing additional cleanup work and leaving some uncertainty whether or not all Microcats could be reused for the next deployment period. All other instruments to be used during the upcoming deployments came straight from the lab, with the exception of one of the moored ADCPs. All mooring activities are summarized in the deployment and recovery tables.

The ship sailed from Mindelo on Saturday morning, February 23. Local time on board is UTC-1. Headed south, we began to prepare the instruments for the first mooring – the MMP station near 8°N, 23°W planned for the early morning of February 26. The Profiler was programmed to perform paired profiles every 1.9 days, following a lengthy discussion on energy consumption, tidal aliasing etc. With this setting, the diagnostic program predicts sufficient power until January 2010 while recovery is planned for November 2009. Microcats were calibrated during the first CTD cast. We decided not to touch the optode on the Profiler but leave the calibration to be done during the recovery cruise. This mooring is in support of the OMZ research project, as is the mooring at 5°N, the latter being a repetition of a pilot mooring deployed during R/V METEOR cruise 68/2 in July 2006.

In the early morning of Tuesday, February 26, we surveyed the intended location of the 8°N mooring and found a suitable place with a water depth close to the planned one – 4480 m corrected. Deployment started at 6:36 local (7:36 UTC). The Profiler was deployed after about 50 m of wire below the stopper has been paid out, trying a new method by slipping a section of Meteor rope through the lower plastic guide of the Profiler, then slowly lowering the instrument into the water, allowing it to descend tail first. We believe this method to be superior to all others we have tried so far. The anchor was slipped at 10:49L without any problems about 10 minutes after the last element went in the water. The anchor drop position was 08° 01.28'N, 22°58.6'W.

The next stop was the 5°N site to recover and re-deploy that mooring, for a full day of mooring-related work. Release of the mooring went very well, and most of the instruments came on board in good physical shape. However, the profiler was entangled in long-line fisheries equipment which prevented any profiling of the MMP after the long-line incident. The question of when this happened remained unanswered initially as the top MTD recorder was flooded and damaged beyond repair, and the Aanderaa rotor located at a depth of 1025 m was also blocked by the same fishing line. However, the records indicated that this entanglement must have occurred about 1.5 months after deployment. Redeployment of the mooring began during the late afternoon on February 27, and the anchor was dropped with a big splash. Submergence of the top elements could not be observed due to the fading daylight. The final mooring position was estimated at 5° 0.9'N, 23° 0.0'W.

With this deployment, the SFB mooring component was completed successfully.

Mooring work was performed throughout the next few days. We began to install the equatorial array with the deployment of the 2°N mooring on February 28. This and other deployments at new sites, not previously occupied, were preceded by a deep CTD cast (to obtain a precise estimate of the sound speed profile), followed by a depth survey with R/V L'ATALANTE multi beam echo sounder. The starting point and anchor drop location were determined by performing a 20 min long drift test. Deployment at the 2°N mooring began in late afternoon, and anchor drop was during fading daylight, allowing submergence to be observed by the ceasing watchdog signal only.

The mooring at 0° 45'N was recovered on February 29 with no surprises. The release responded properly, with good ranging and immediate release. The top element was heavily overgrown, but the wire farther down was almost clean. Instruments looked good and a first data inspection indicated a somewhat shallower top than planned.

The day after, March 1, at 06:15L we released the mooring at the equator - including the WHOI-supplied profiler (J. Toole). The mooring came up immediately and the first elements went on deck. To our surprise, the profiler was found at the upper end of the wire. The wire jacket was damaged over most of the upper 1000 m, and we decided to get the profiler first so it would not slide down all the way along the rough wire. It turned out that the profiler had worked to the end, but the range was considerably reduced following a few months of full depth range. The damage must have occurred during the recovery operation, also confirmed by the blank, non-corroded wire elements.

In the afternoon we redeployed the equatorial mooring – this time with the wind on the stern, to avoid being caught again by the EUC (as happened during M68/2). However, the EUC-caused problems did reoccur, albeit to a much lesser degree. We were able to solve the wire angle problem without major complications. This mooring featured a Tip-Top (see Fig. 4.7) above the regular mooring configuration, to be recovered on our way back. The first mooring with 3 ADCPs was deployed during early evening, and darkness prevented us from observing the submergence of the top float. The radio signal from the Tip-Top ceased and was not heard again, providing great relieve as the top element was planned to be shallower than 40m depth.

The morning of March 2, we were at the mooring site at 21.5°W and the equator. About half a year earlier, the Argos beacon on this mooring had alarmed us of a drifting top element, so we were anxious to see what was still left of the mooring. At the site, both releases responded and released promptly. We found everything in place, missing only the 32" foam float with one MTD and the Argos beacon. The remainder of the mooring was in good shape, and it appeared that the ADCP had not suffered from being pulled down by the bitter end of the wire and 3 Microcats along this wire. However, the Microcats showed spurious spikes after the event.

On March 3, we arrived at the site of the 2°S mooring, and we had already concluded earlier that the topography at the chosen site was very unfavorable. The only really good place was a valley which was 400m too deep and could not be used due to wire limitations. A multibeam echo sounder survey showed another location of sufficient flatness and proper depth (4840 m). To be on the safe side, we decided to allocate 5 h for the mooring work, leaving sufficient time at the end to tow the mooring into place. This worked out fine, except it took more time than expected, and the final mooring location ended up at 1° 56.70'S, 22° 56.65'W.

The mooring at 0° 45'S was replaced on March 4. Mooring recovery started in the early morning, and after both releases responded properly, the mooring was released at sunrise (06:15L). The mooring was sighted shortly thereafter, but all elements were clustered at the same location, making the pickup extremely difficult. We then picked the most exposed group which turned out to be located in the middle of the mooring. However, when the top was finally retrieved, more fishing line was found which apparently had sheared off the uppermost MTD. Two Aanderaa rotors were lost during recovery due to the long-line tangles.

After lunch we began to re-deploy the mooring at the same location which went well without a hitch. Please note that the upper Microcats were shifted upward slightly, as noted in the protocol. We towed the mooring into place and dropped the anchor in heavy rain. However, submergence could be observed, and once again, the final position was almost exactly as planned. After waiting to make sure that the mooring did not resurface, we left the site for the next CTD station.

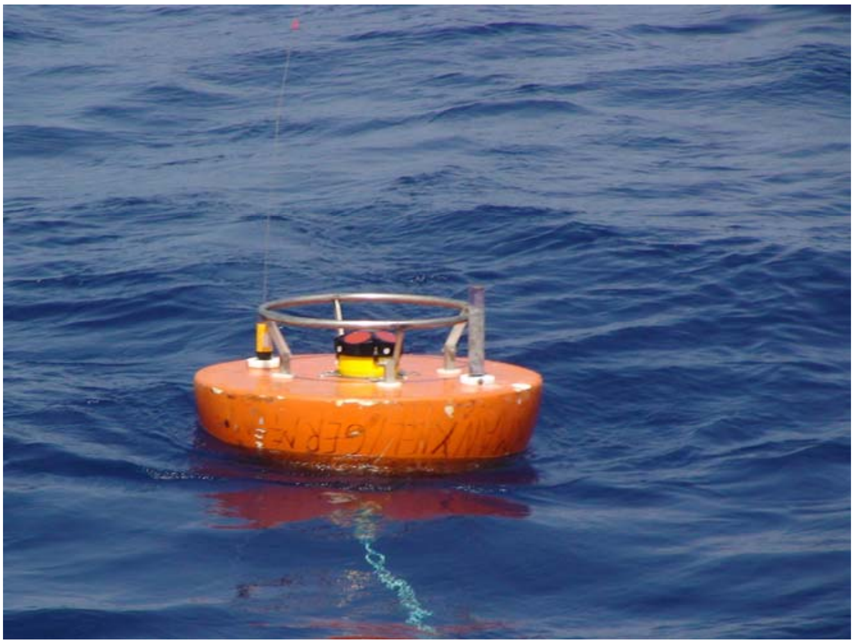


Fig. 4.7: Tip-Top element carrying the 1200 kHz ADCP atop the regular equatorial mooring at 23°W.

On March 5, we were back at the equator to recover the Tip-Top of the equatorial mooring deployed five days earlier. We first determined the position by minimum distance search, then moved the ship into position 150 m off the point, released, and immediately located the floatation half sphere, even though nobody actually saw it popping up. The ADCP was still pinging and sampled more than 200 MB of data in 4 days.

The last mooring of the equatorial array was installed March 6 very early in the morning (04:00 L drift test, 06:00 L first element in water). This mooring was at 4310 m water depth and we had to add 100 m of wire (remove 20 m; add 3 x 40 m). Aiming for a deployment length of 3.5 h, we were almost ready to drop the anchor when we passed the launch position (~100 m overshoot). The anchor (1450kg) was dropped with a splash, filmed this time from the Zodiac. Then we observed the submergence of the top element which appeared to move much slower through the water than in the other moorings. On standby, we waited for about one hour for any re-appearance of the watchdog signal, but everything remained quiet, indicating a successful deployment. The top Microcats were moved up the wire, with the upper Microcat at 94 m (s/n 2251 to 143 m), and MTD s/n 31 moved to 298 m.

On March 14 at 04:00 L, we started the drift test for the redeployment of the TENATSO mooring, and at 06:00 L the top element including a fluorometer, a Microcat and an ARGOS watchdog, went into the water. The whole mooring deployment took about 4 hours, and the anchor was dropped at the planned position. Submergence of the top element was observed. Since more than one hour later no ARGOS signal had been received, we deemed the mooring successfully deployed. During lunchtime, microstructure measurements were carried out and at 14:00 L, while preparing for the deployment of the Inverted Echo Sounder, we observed the top element of our mooring located right at the surface, at times flushed by the waves. It soon became clear that the top element was still attached to the mooring, but at least 40 m shallower than expected. The only option without releasing the entire mooring was to cut off the top element. In this case, 34 m of mooring, with two Microcats attached, would drop down below the next Benthos group (see Fig. 4.8 for a schematic of the mooring configuration). They would represent no harm for the remainder of the mooring as long as the new top element would stay deep enough below the surface. As there was the possibility that the top element would re-submerge due to changing currents, we quickly decided to use the Zodiac to attach a rope via the ship's A-frame to the top element. The captain skillfully drove the ship backward to stop exactly in front of the top element.

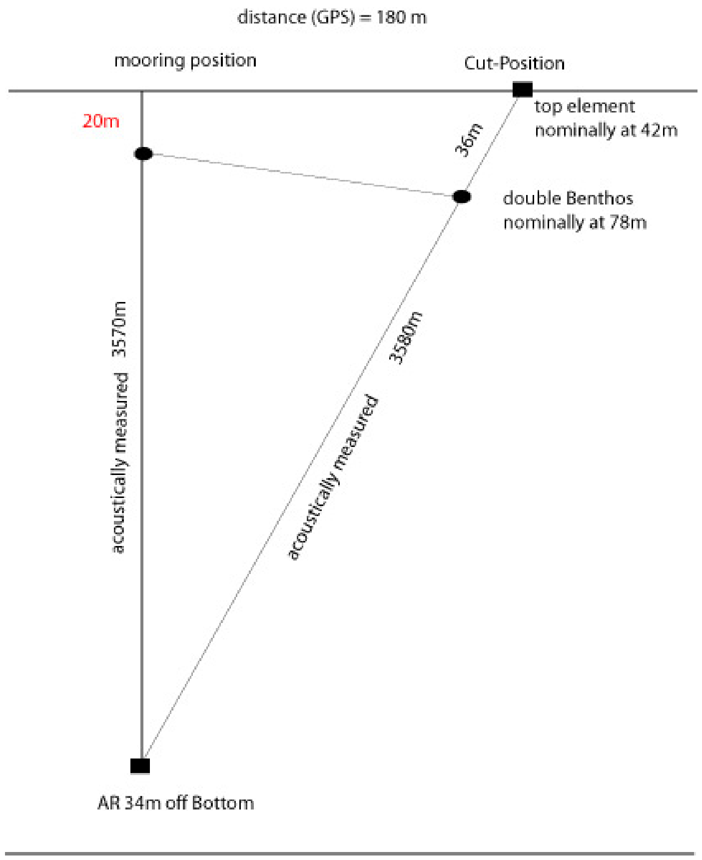


Fig. 4.8: Schematic of mooring configuration which lead to the resurfacing of the top float of the TENATSO mooring. The 36 m piece in the upper right-hand corner was cut.

At 16:15L the top element was picked up and heaved out of the water using the ship's capstan. After a haul of only two to three meters, the tension on the mooring wire became very severe. The wire was cut below the top element at the position of 17°36.198'N, 24°15.004'W. This cut position was only about 180 m horizontally from the location of the release position determined through subsequent triangulation, i.e. 17°36.244'N, 24°14.915'W. Note that this location is closer to the anchor drop position than expected, with the backdrop of the anchor only about 9% of the total mooring length. The distance between the top element and the release direct following the cut was about 3580 m (corrected for hydrophone depth and sound speed). The mooring program indicates this distance to be no more than 3523 m (the distance between release and top element from the mooring program). Therefore, in case the mooring was fully stretched, the total length of the mooring was about 60 m too long. An error in the water depth is very unlikely. The different pressure/depth records from the last mooring period consistently indicate a water depth at the mooring position of 3594 m. Moreover, during our last cruise, we made a detailed bathymetric survey using the multi-beam echo sounder of R/V METEOR. The obtained topography - corrected using an observed sound speed profile - revealed water depths around 3600 m with only 10 m variations over a very large region. This was confirmed by the deep CTD profile just prior to the mooring deployment that was stopped 15 m above the bottom (as measured by the CTD altimeter and the lowered ADCP), indicating 3584 m as measured by the pressure sensor and converted to depth. Also, the echo sounder of R/V L'ATALANTE showed very smooth topography with only slight variations around 3600 m during the CTD cast and during the mooring deployment. From the triangulation of the releases after severing the top element, we obtained the depth of the releases to be 3570 m. As the releases are nominally 34 m above the anchor, the total water depth at the mooring position should be 3604 m. From the proximity of the cut position to the actual mooring position we conclude that the mooring wire was almost completely stretched and that after cutting the top element, the next Benthos group is about 20 m below the surface, and the risk for rising to the surface during low current conditions is deemed to be small. We believe that the only explanation for the surfacing of the top element is a mooring longer than planned. We must check with the manufacturer of the mooring wire if such a mistake is possible and can be prevented for any future deployments.

The inverted echo sounder was then deployed without problems at 17:10 L near the mooring at 17°36.031'N, 24°14.604'W.

During the above-described decision making process, we noticed some range inconsistencies with one of the new release units (#270) of about 30 m. This was confirmed later by comparison with its counterpart in the mooring and by inspection of the release tests. Another pair of releases with the same type of instrument showed the same behavior (30 m more range than its counterpart). Thus, this type of releases should be treated with caution when range determination is important.

4.4.3.1 Moored Instrument Performance During 2006-2008

The data retrieval was similar to other mooring efforts in the past (Fig. 4.9). We got all moorings back and most of the instruments contained full data sets. Most painful was that both MMPs had only partially fulfilled their mission. The one at 5°N was hampered by fishing equipment after only 1.5 months, and the equatorial one gradually decreased its profiling range for reasons unknown so far. Major concern with the ADCP data was the apparently incorrect data of the equatorial Workhorse and possibly a heading problem of the northern Narrowband ADCP.

Table 4.1: Standard instrumentation vs. moored profilers

Instrument Performance 2006-2008	Standard Instr. (%)	Moored Profiler (%)
Moorings	100.0	100.0
Currents	95.0	28.0
Temperature	92.7	28.0
Conductivity	93.8	28.0
Pressure	87.0	28.0

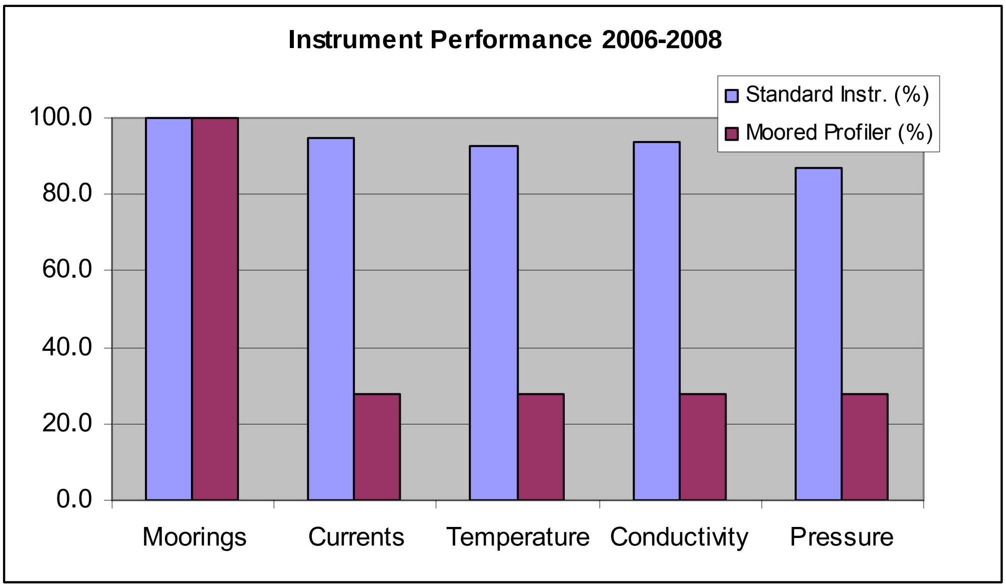


Fig. 4.9: Percentage of moorings/parameter data retrieved for the 2006-2008 deployment. The reduced data amounts obtained from the profilers are due to the range and time limitations from long-line entanglement and unknown causes (see text).

4.4.3.2 Calibration of Moored Instruments

Moored instruments (Microcats and MTDs) are typically subjected to a pre-deployment or post-deployment calibration by lowering them during a regular CTD cast and using stabilized data obtained during 2-minute stops at pre-selected depths (or water mass properties) for calibration points for temperature, conductivity and pressure, if available. Linear fits are used to determine calibration factors which are then applied to the moored records (Fig. 4.10).

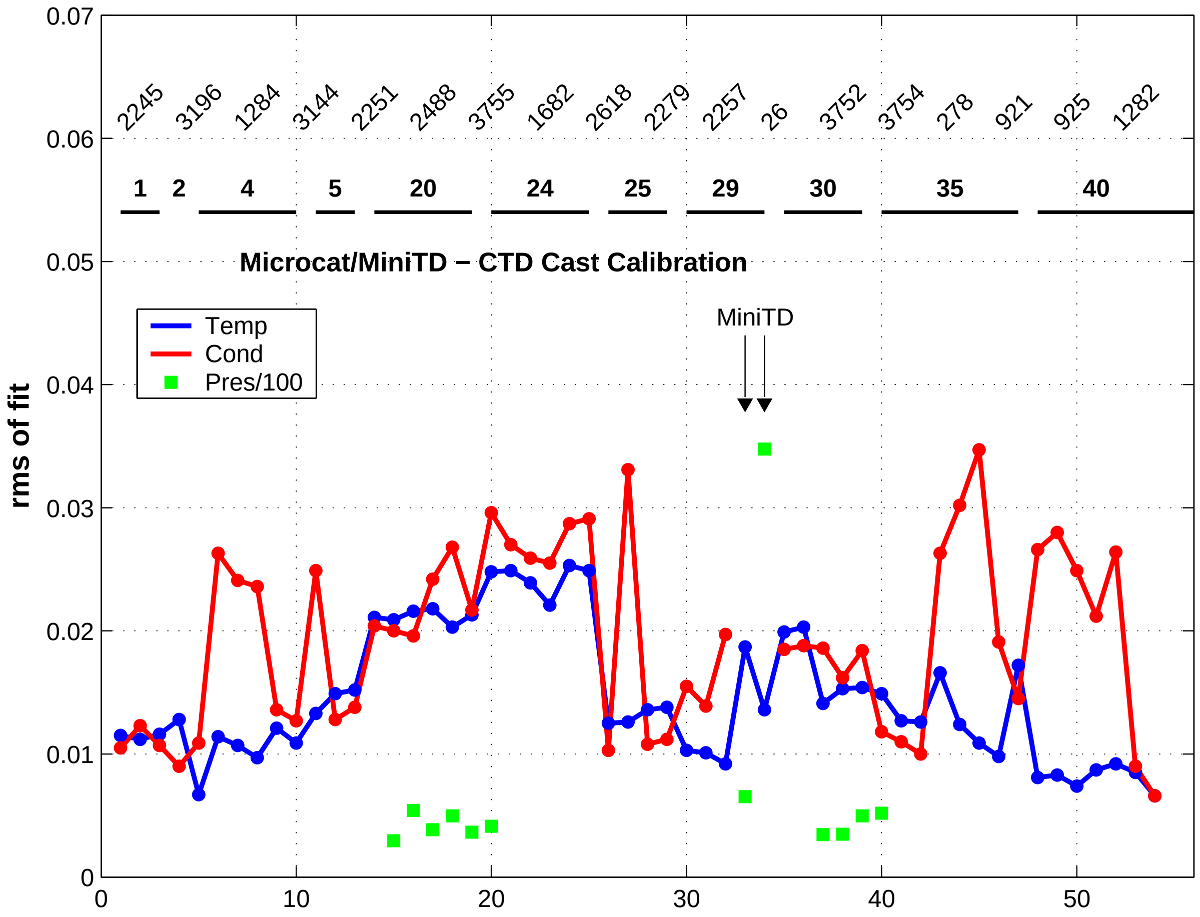
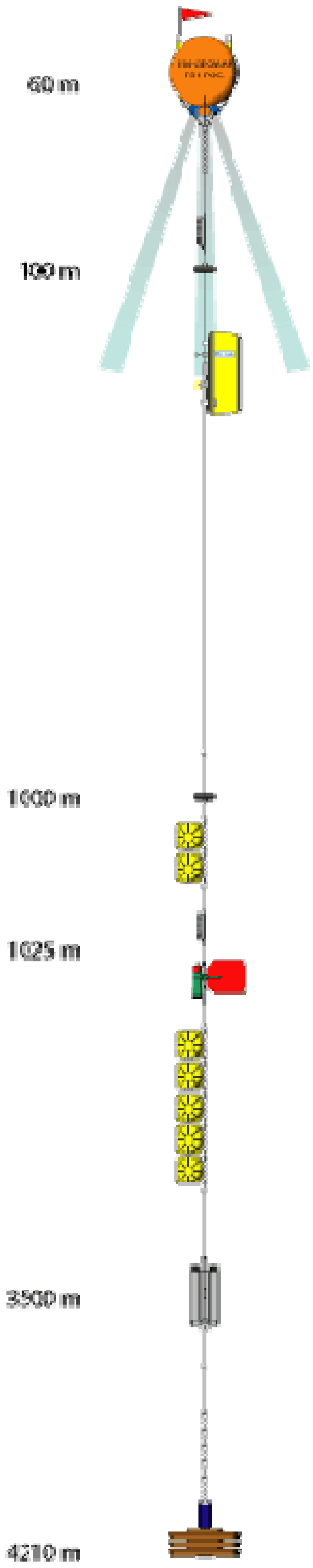


Fig. 4.10: Residual of linear calibration fits for temperature (blue), conductivity (red) and pressure (green, scaled by factor of 1/100) as a function of serial number and CTD cast. The quality of some fits may vary due to sea state, ship's pitch and roll, and other effects. The resulting calibration factors are listed below.

4.4.3.3 McLane Moored Profiler



The MMP is a modern observing platform for physical and chemical in-situ measurements over long time intervals. Powered by lithium batteries, an electric motor drives a friction wheel for climbing the mooring wire up and down at slow speeds. One million meters is the total traveling range, e.g. 500 profile pairs of 2000m total length (1000m up and down, respectively) can be performed.

On R/V L'ATALANTE cruise IFM-GEOMAR - 4, we had two of these instruments aboard and two were to be recovered. As we approached the 5°N mooring relatively early during the cruise, we were anxious to see how this instrument had performed. The mooring structure is shown to the left (Fig. 4.11). Unfortunately, the profiler suffered a major entanglement with long-line fishing equipment, and data inspection showed that this happened early during the deployment period – after about 40 days, thereby bringing the profiler to a complete stop.

During the total deployment period, this mooring seemed to suffer several attacks by long-lines, with August being the preferred month. Thus there is some concern for the replacement mooring that was deployed at the same location.

However, while the profiler was running properly, it performed the cycle as programmed: one up and down cycle, followed by a waiting period of 1.6 days. Two aspects have been investigated in more detail. The first was the oxygen measured by an Aanderaa optode, apparently requiring post-deployment calibrations and a rather long time constant correction of the sensor foil. Nevertheless, the measurements offer tremendous potential for the new SFB research on OMZ.

The second aspect was the velocity measured by the FSI-ACM aboard the MMP. The mooring also featured a down-looking ADCP with large overlapping ranges for comparison.

The Seabird Microcats above and below the profile range as well as the Aanderaa Rotor Current Meter will also be used as references for the CTD and current measurements of the moored profiler.

Mooring AO_05 with full instrumentation, MMP, LongRanger ADCP, Aanderaa Rotor Current Meter, and two Seabird Microcats.

Fig. 4.11: Schematic of Mooring AO_05

One and a half month of high resolution oxygen profiles reveal the potential of MMP measurements with Aanderaa optodes. The oxygen measurements capture the oxygen minimum at about 400m and show strongly inclined oxygen anomalies on short time scales. The obtained oxygen data from up and down profiles also reveal the presence of a strong hysteresis inherent with optode measurements (Fig. 4.12, upper panel). However, the hysteresis cannot be attributed to the temperature measurements inside the optode: The effect of correcting the optode temperature using the CTD temperature from the profiler is small compared to the remaining hysteresis. Using a simple calibration accounting for a time constant of the oxygen sensor, we are able to reduce the hysteresis in the oxygen data (Fig. 4.12, lower panel). The optimum, yet rather large time constant of about 40 s was obtained by searching for a minimum in the standard deviation of the difference between successive up and down profiles. The final calibrated MMP oxygen values fall in the range of previously obtained shipboard measurements showing a high variability of the oxygen at 5°N, 23°W (Fig. 4.13).

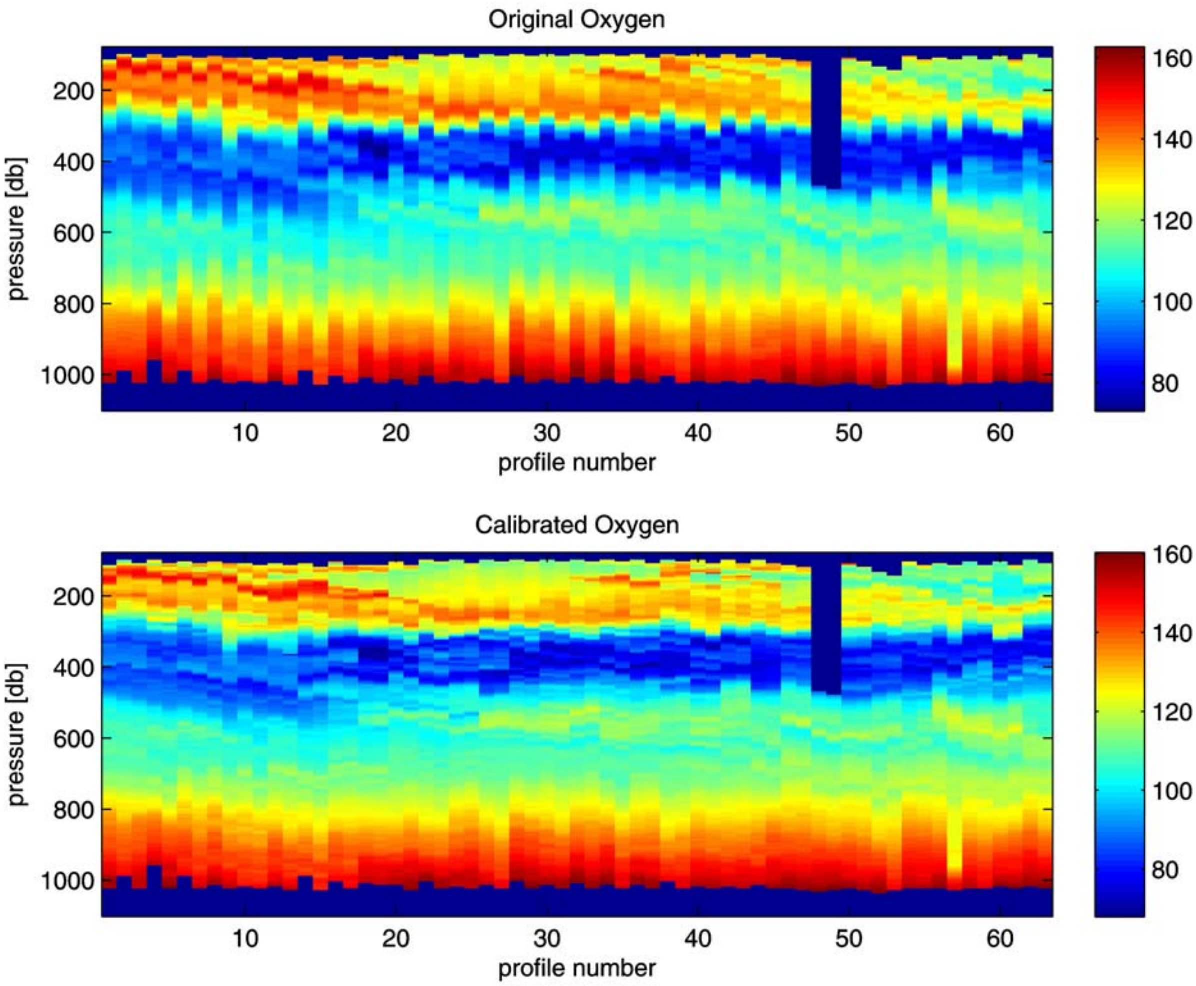


Fig. 4.12 Oxygen profiles [µmol/kg] from MMP at 5°N, 23°W acquired from July 4 to August 22, 2006. Uncalibrated oxygen data showing a strong hysteresis are depicted in the upper panel. Calibrated oxygen data are obtained by applying a time constant calibration and standard calibrations as discussed in section 4.4.1.3.

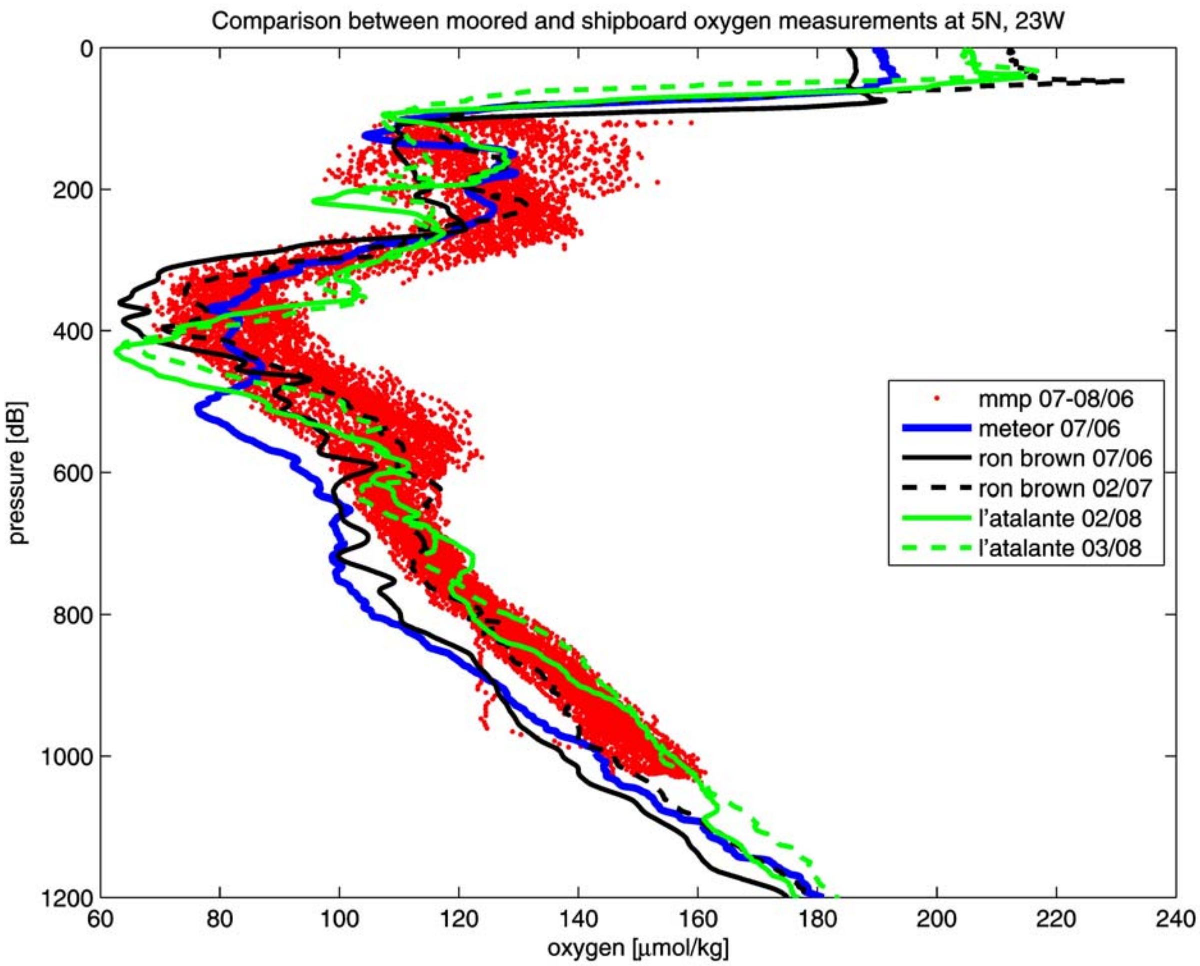


Fig. 4.13: Oxygen measurements at 5°N, 23°W from different shipboard CTD measurements (dashed and solid lines) and from MMP.

The second topic of interest was a comparison of the velocity measurements of the MMP and a downward looking Longranger ADCP. In a first step, the raw MMP-velocities were corrected for magnetic bias and for instrument motion using a software packet provided by J. Toole (WHOI). The data were initially gridded and contoured (Fig. 4.14), followed by an interpolation of the MMP velocity to the vertical resolution of the LR-ADCP. A feature comparison between individual MMP profiles and adjacent LR-ADCP profiles allowed a temporal synchronization in the next step, yielding both velocity fields on the same space and time grid, and in turn allowing a first comparison (using the LR-ADCP data as a reference). The overall means of the two fields are indistinguishable (< 0.02 m/s), with rms differences in layers around 4 cm/s (see Fig. 4.15). Altogether, this is a promising outlook for the quality of the MMP velocity measurements.

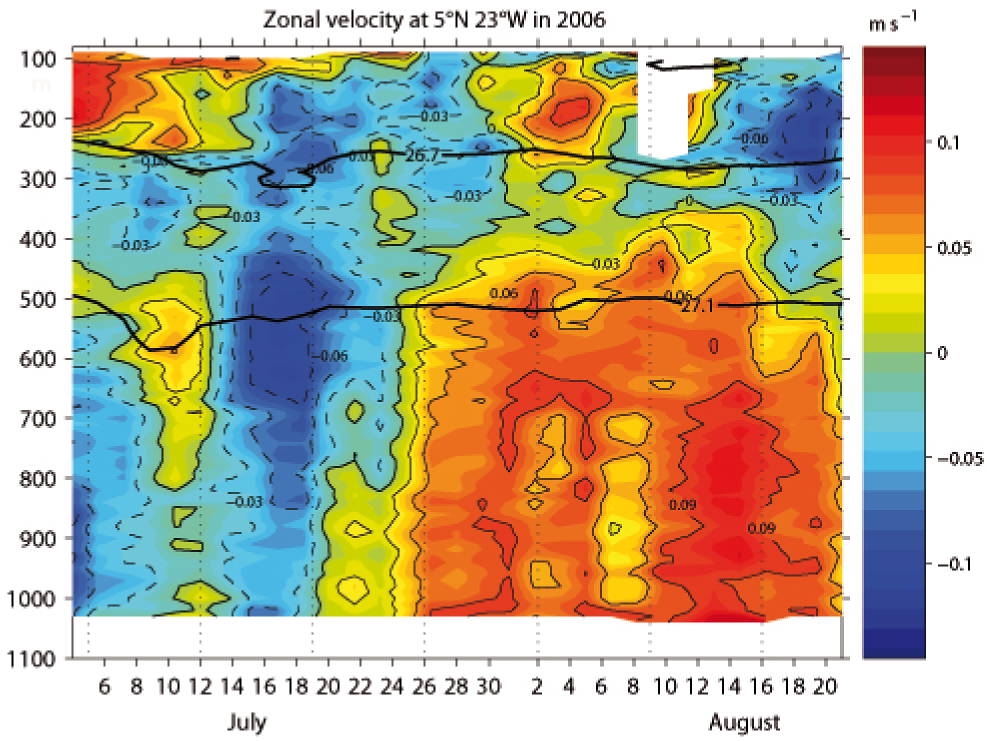


Fig 4.14: Zonal MMP currents at 5°N (depth [m] vs. time). Data were subjected to the J. Toole correction routine and subsequent gridding.

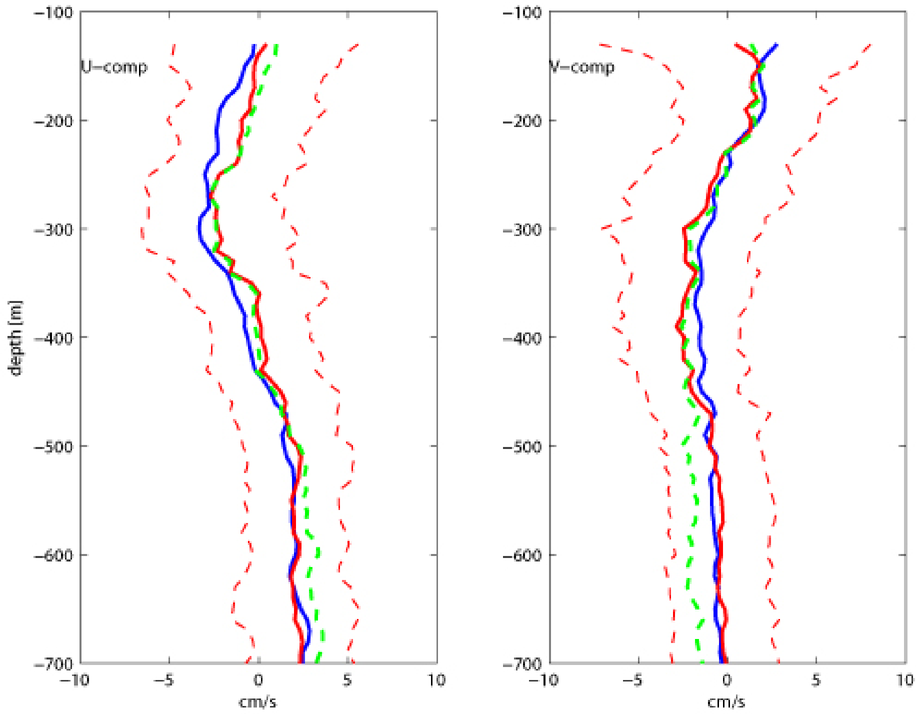


Fig. 4.15: Comparison of LR-ADCP (blue) and MMP (red) velocities. Dashed lines are rms differences between the two, calculated for 10m depth cells; here enveloping the MMP profile. The effect of MMP bias correction is illustrated by the dashed green curve, representing the MMP profile without the correction.

4.4.3.4 Selected Results

Flow in the equatorial belt

To illustrate the richness of the data set, we here show the current distribution in one of the depth layers, at 700 m, in their geographical arrangement. The middle row in Fig. 4.16 is at the equator (23°W and 21.5°W) and the upper and lower graphs are at 23°W, 45'N and 45'S, respectively. Note the intense variability (instability waves) on short time scales with some correlation of the larger events (e.g., northern and equatorial mooring at 23°W). The maximum flow in September 2007 can be detected in all four records.

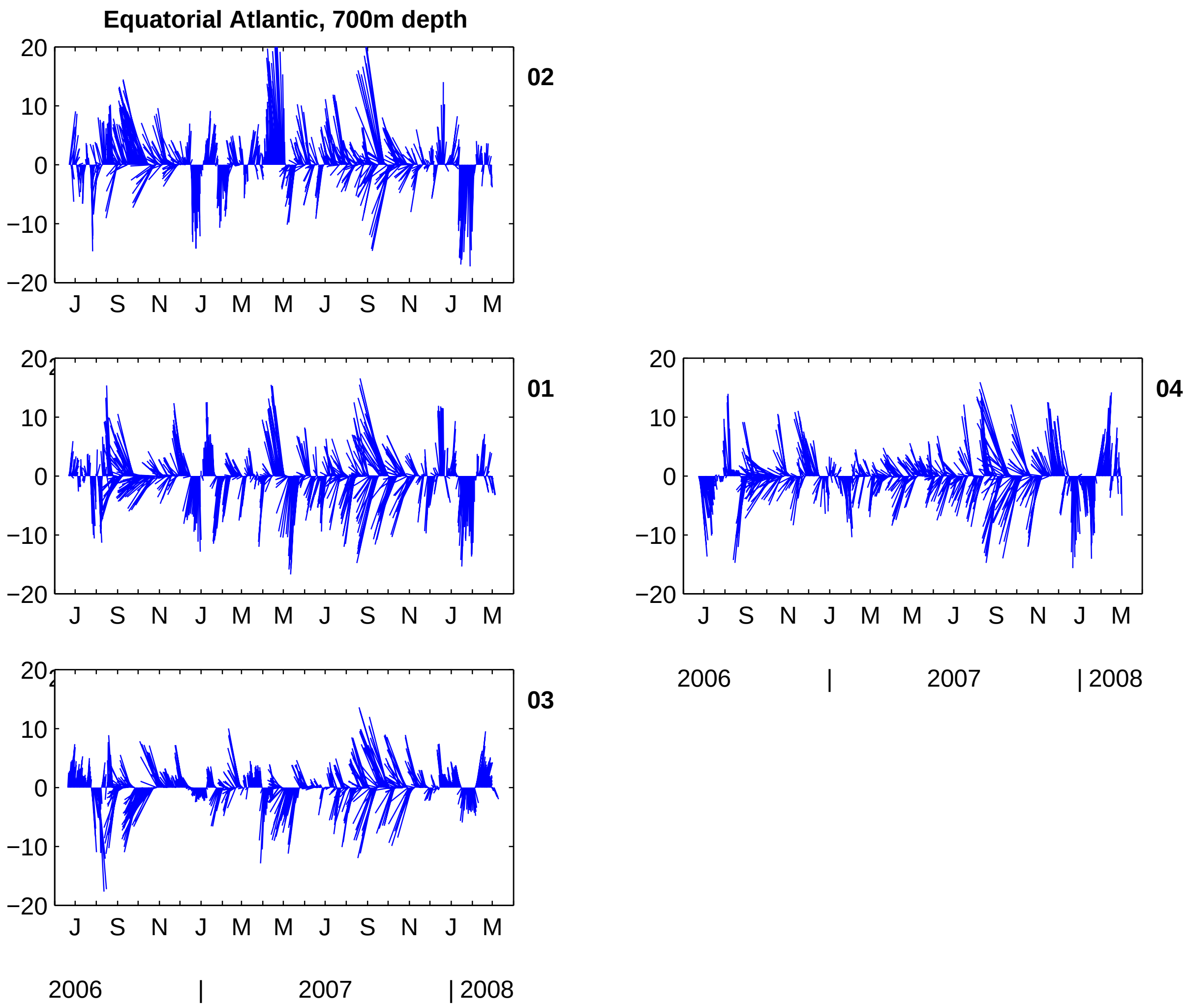


Fig. 4.16: Stick plots of equatorial flow field at 700m level, (upper graph for 45'N, 23°W, middle for equator, 23°W and 21.5°W, and lower for 45'S, 23°W)

For the upper layer we show the four ADCPs located in the upper range of these moorings (Fig. 4.17). Narrowband ADCPs transmitting at 150 kHz were use in the off-equatorial moorings, looking upward from about 300m depth. The northern instrument seemed to have problems with its heading, requiring a post cruise compass calibration which was performed in Kiel on June 4, 2008. Both NB-ADCP were placed on a turntable, rotating the instruments by 360°, and comparing the readings to those of a reference magnetic compass in a magnetically undisturbed area. We found no significant deviations from the reference readings and therefore the ADCP direction data as being reliable.

Longranger ADCPs (75 kHz systems) were used in the equatorial mooring and at 5°N (see MMP discussion). At a first glance, all LR-ADCP worked well without any apparent compass problems.

However, this is not the case with the 300 kHz ADCP at the equator. This instrument shows very strange behavior (large vertical and error velocities), and no reasonable explanation for why this happened. Currently this data set must be regarded non-usable. This ADCP has been sent to RDI-Europe for inspection / repair.

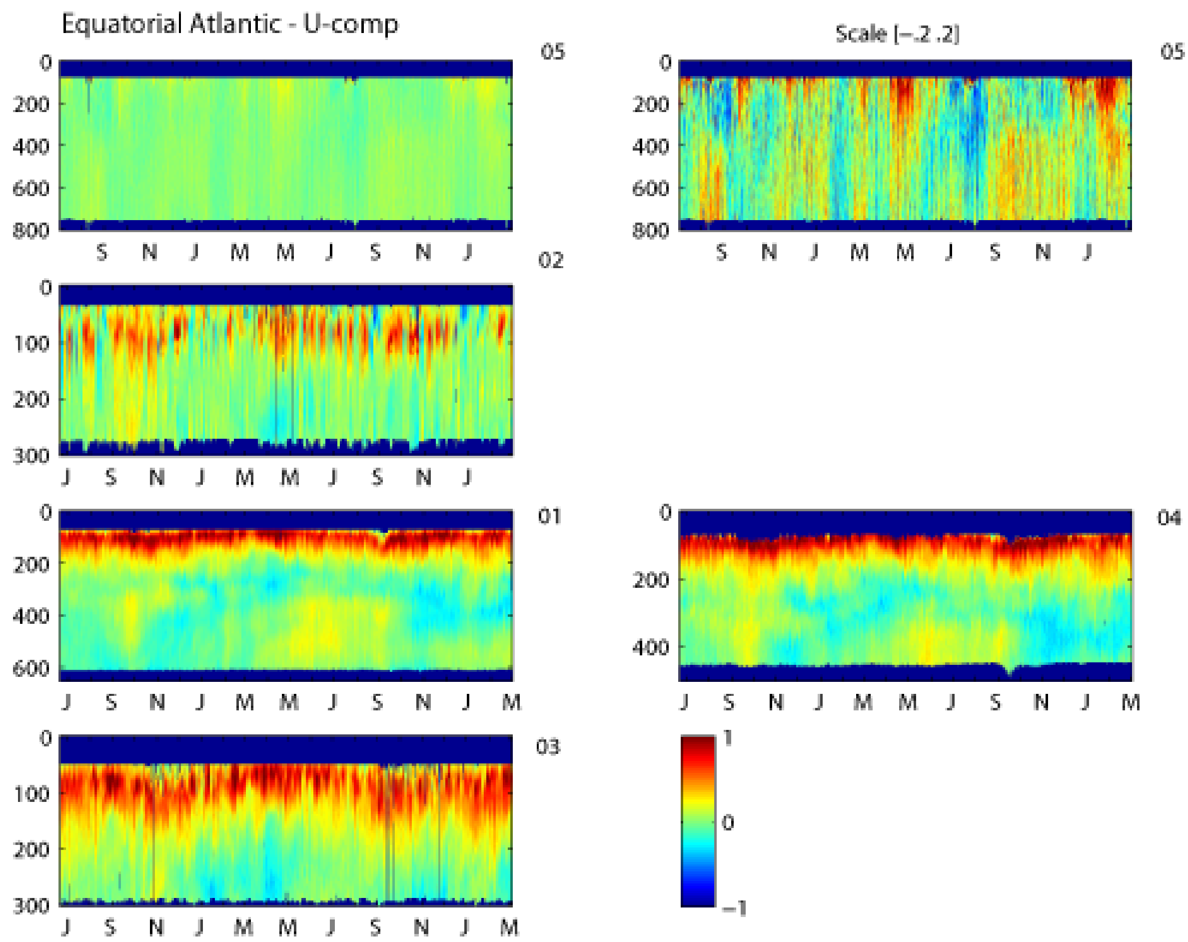


Fig. 4.17: Zonal flow in the upper layer of the equatorial Atlantic as measured by ADCP. Left column from top to bottom: instrument at 5°N, 0°45'N, Equator, 0°45'S, and right column at top (zonal flow at 5°N with velocity scale -20cm/s to +20cm/s) and middle right is for equatorial ADCP at 21.5°N.

<u>1200 kHz ADCP at the equator</u>

The equatorial mooring at 23°W had an additional high frequency ADCP attached to the top buoy (a so-called Tip-Top, see photo in Fig. 4.7) aimed at measuring turbulent flow in the upper 40m; i.e., at the upper edge of the EUC (Fig. 4.18). However, the depth of this ADCP was somewhat shallower than planned, and during short periods of weak flow, it rose up to about 5 to 10m, barely safe below the surface. However, since this deployment was for a short period of 4 days only, we deemed any risk for the main mooring to be small.

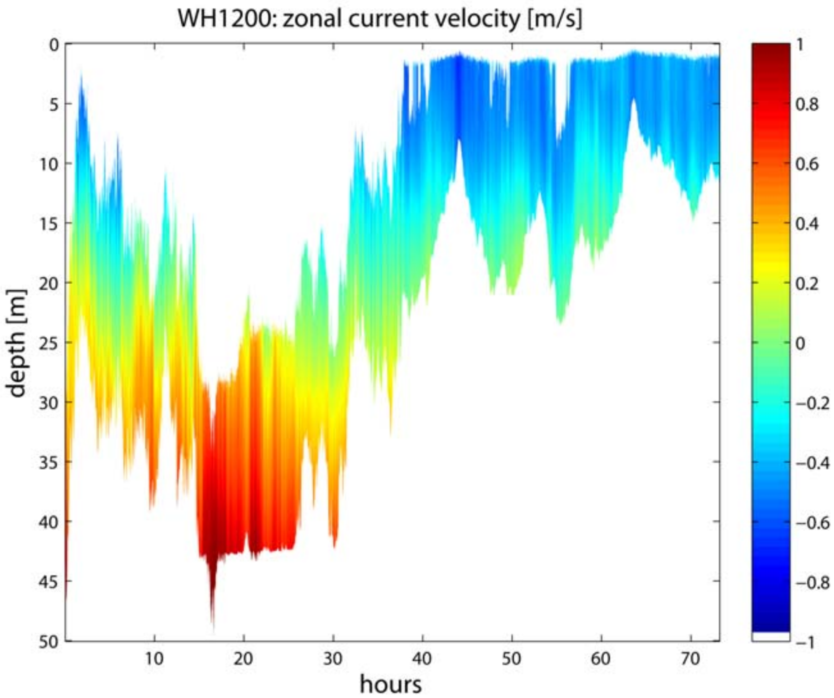


Fig. 4.18: Zonal velocity [m/s] at the equator, 23°W above the EUC as measured from a short term mooring (March 1st – 5th 2008) using a 1200 kHz upward looking ADCP. Surface distance varies with mooring motion.

This ADCP had been programmed to measure in beam coordinates with mode 12, meaning raw internal Doppler averaging of fast pings and storing thereafter. During the 4-day operation, the instrument sampled more than 200MB of data. These were transformed and depth-shifted. The zonal flow shows an average vertical shear of about 0.035 s^{-1} along the entire depth range scanned.

4.4.4. Glider Recovery/Deployment

Two autonomous glider systems manufactured by Webb Research were used during the cruise. With the intention of covering a section along 23°W from the Cape Verde Islands to the equator one system, IFM03, was launched from near Mindelo on January 11. After spending a few days near the deployment location to test whether everything was functioning properly it was on January 16 sent southeast towards the northern end of the section at 14°N 23°W. The glider reached this position on January 30. It then turned south and traveled until February 25 when it was recovered near 9°35.5'N, 23°1.1'W (see Fig. 4.19 for the track). This was for our group the first successful long distance glider mission with this type of glider. During this mission and a companion deployment near the Cape Verde Islands the endurance of the battery packs was evaluated. We found that with the battery configuration and the sensors in use the distance was limited to about 1000 km. A somewhat longer distance should be possible when reducing the speed of the glider by pumping less oil. This was however not feasible during this deployment as the possible recovery dates were fixed by the times when R/V L'ATALANTE would pass the glider and we wanted to cover as much distance within this fixed time frame.

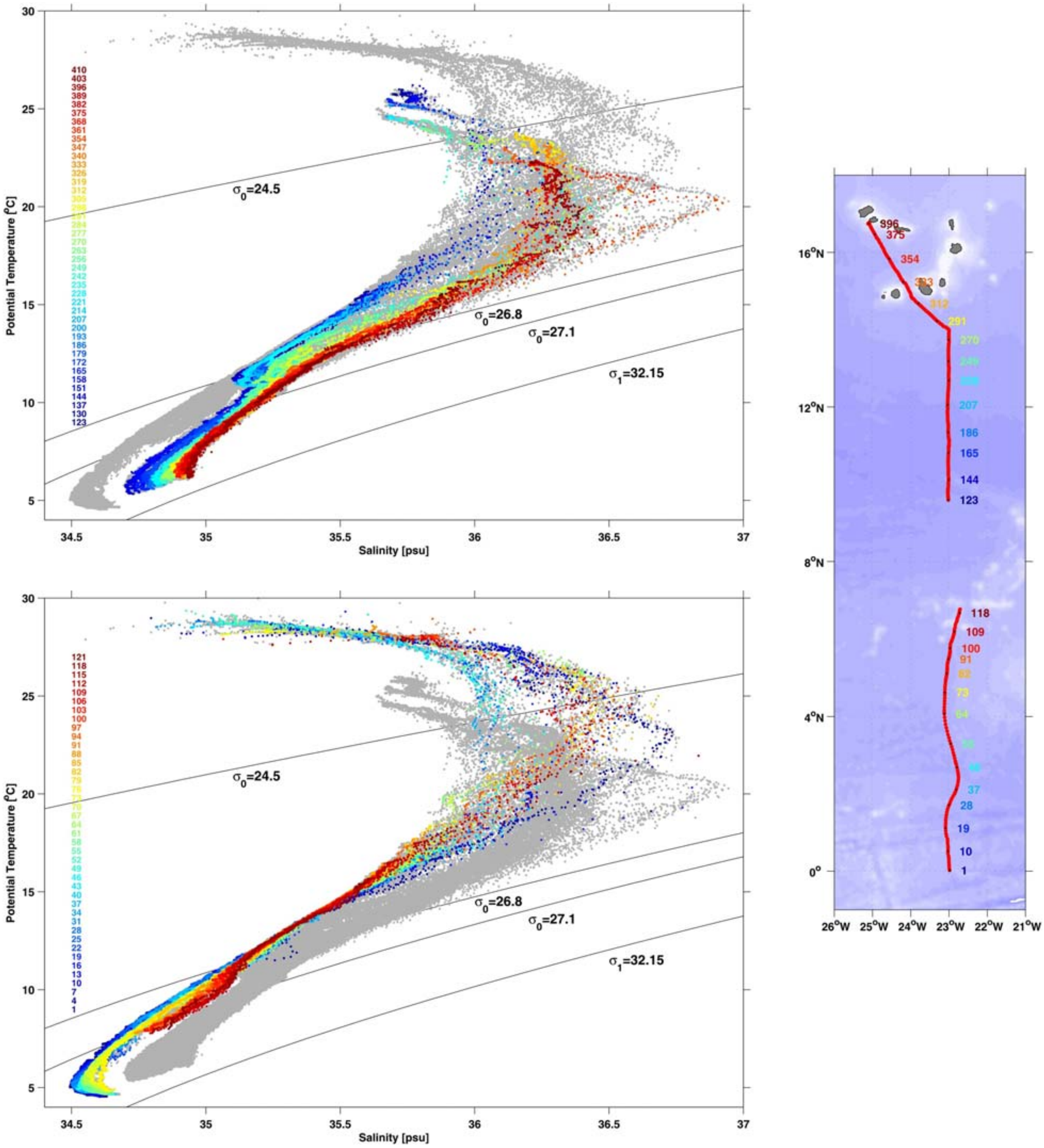


Fig. 4.19: θ-S-diagrams of glider IFM03 (upper left) and IFM02 (lower right). In the θ-S-diagram the colors denote the number of the respective profile as indicated in the track map.

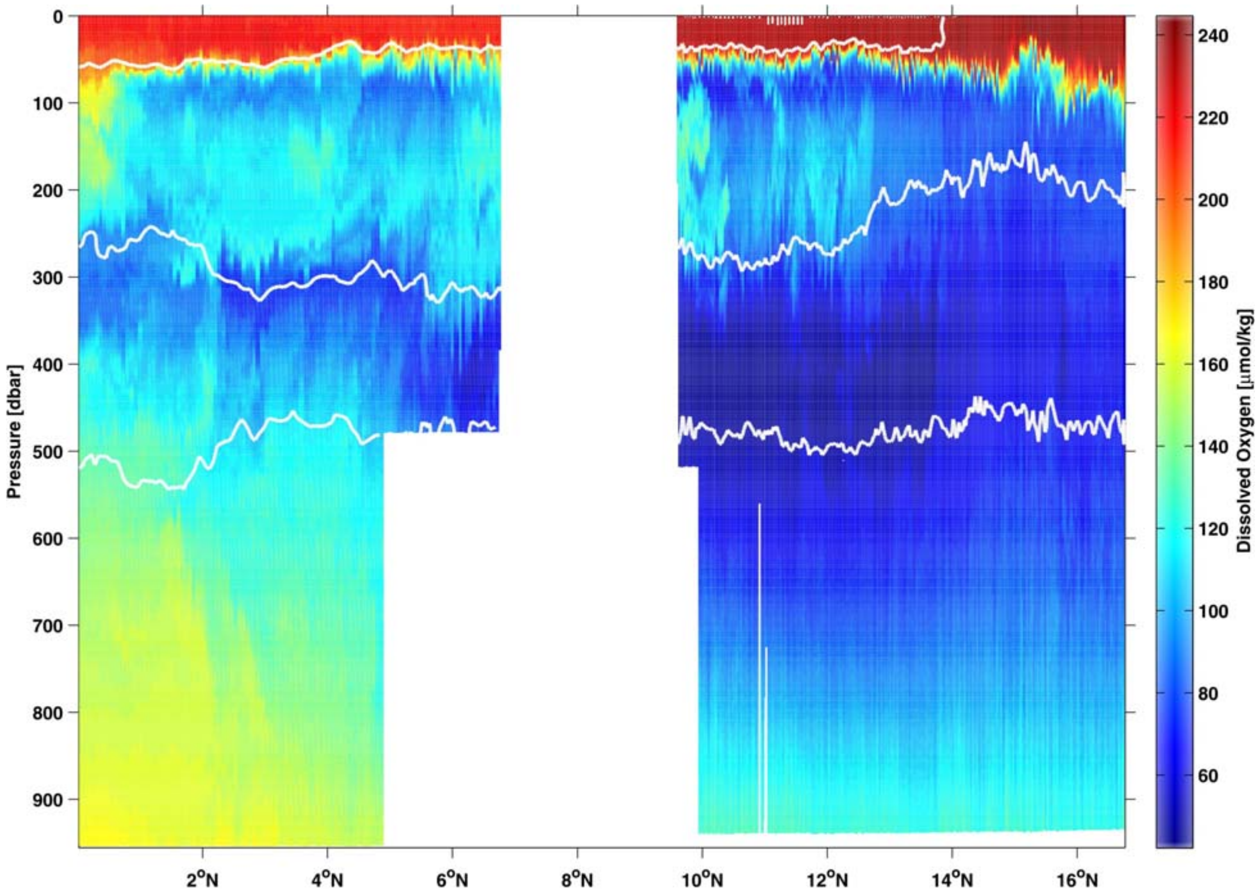


Fig. 4.20: Oxygen distribution as observed by glider IFM03 (northern part) and IFM02 (southern part). White lines show isolines of σ_θ=24.5, σ_θ=26.8, and σ_θ=27.1kg/m³. Glider tracks are given in Fig. 4.19.

During the whole deployment the sensors of the glider, a Seabird CTD system, an Aanderaa Oxygen measuring Optode (Fig. 4.20), and a Wetlabs Fluorometer, worked without problems. The glider made more than 300 dives, 258 of which were to 980 m depth and resulted in good data. The remaining profiles were shallower down to 500 or 200 m and were collected during the initial test and later shortly before recovery when the batteries were already running low. The number of dives translates into an average distance between profiles of about 4km. Comparison of the average of the glider's last three deep CTD profile with a CTD profile collected on R/V L'ATALANTE nearby but several days later showed that the temperatures and salinities below 100m differed by 0.18 degrees and 0.015 psu rms, respectively. A final comparison of the CTD collected on R/V L'ATALANTE with the glider's data will be made once the CTD data has been calibrated. For calibration purposes the Aanderaa optode was removed from the glider and connected to a data logger. During one profile this system was attached to the CTD. Together with bottle samples calibration coefficients were developed for the optode.

The second glider operation on R/V L'ATALANTE was the deployment of IFM02 (Deepy). On this glider the science bay of IFM05 had been installed after the CTD data collected by the original science system on a previous deployment appeared to be problematic. IFM02 had been tested during a 3 day deployment off the Cape Verde Islands prior to the cruise. The glider was put to the water on February 29 at 0°1.4'N 22°58.5'W. After an initial 30 m test dive, a first deep dive to 800 m was commanded. On both dives no problems were encountered. It was then sent north with double dives between surfacings. The dives have a particular depth pattern in order to conserve energy. The glider descends from the surface down to 980 m, climbs to 200 m, dives again to 980 m, and then comes back to the surface. Using this pattern the pumped oil volume can be greatly reduced as the glider avoids every other climb into the very low density waters above 100 m depth.

We came again close enough to the glider for freewave radio connection on March 6 at 0°53.4'N 23°2.5'W. A number of full data files were downloaded and some parameters changed to improve operation of the glider. In particular it has problems to get GPS positions and to establish Iridium contacts. We suspect that the Antenna, which is used both for GPS and Iridium, is not well matched. IFM02 was recovered from FS Maria S. Merian (chief scientist W. Ekau) at April 14 at 6°57.1'N, 22°24.4 'W.

On R/V L'ATALANTE all glider operations in the water were done with the help of a zodiac inflatable. For the freewave radio system the antenna was installed above the bridge deck with a 6m long cable running into the bridge where it was connected to a Webb dockserver laptop. With this setup we were able to get good connections at distances up to 3nm. Near the equator in very calm seas intermittent radio contact was made at distances up to 6nm. The quality was however not sufficient to send commands.

4.4.5 Microstructure Measurements

A microstructure measurement program was carried out within the frame work of the Junior Research Group (DFG Emmy Noether-Nachwuchsgruppe) "Microstructure" and the BMBF-Surface Ocean Processes in the Anthropocene (SOPRAN) project. The projects aim at quantifying the impact of diapycnal mixing processes on the variability of sea surface temperature and on improving estimates of diapycnal fluxes of heat and biogeochemical tracers from the deeper ocean into the oceanic mixed layer in the upwelling regions of the tropical Atlantic.

Enhanced microstructure sampling was carried out in three regions: Within 1° of the equator, at the Tropical Eastern North Atlantic Time Series Observatory (TENATSO) station northeast of Cape Verde and within the oxygen minimum zones around 23°W, 8°N. In the equatorial region, measurements were performed to resolve mixing processes associated with elevated background shear due to the presence of the EUC. Here, night time enhancement of turbulent dissipation rates in the stratified water column was observed during previous cruise and the measurements aimed at a better understanding of relevant physical processes. At the TENATSO station, long duration measurements were performed to investigate diapycnal fluxes of chemical and biological parameters to improve understanding of biogeochemical processes in the water column. Finally, measurements within the oxygen minimum zone were conducted to study processes leading to diapycnal fluxes of oxygen that may be relevant for the total oxygen budget in this region.

Technical Aspects

Microstructure measurements were sampled using a microstructure measuring system consisting of a loosely-tethered profiler, an electrical winch supplied with 900 m Kevlar cable, and a deck unit. The system was manufactured by ISW-Messtechnik in collaboration with Sea and Sun Technology (Trappenkamp, Germany). The profiler in use during the cruise was of type MSS90-

D (S/N 032). The winch was mounted to the gunwale at the port-side stern of R/V L'ATALANTE. The MSS90-D profiler operates 16 channels with a high data transmission rate (1024 Hz) which is sufficient to resolve micro-scale gradients (~0.6 mm) of velocity shear and temperature that can be used to infer turbulent fluctuations in the ocean. It was equipped with two shear probes (airfoil, 4ms response time), a fast-responding temperature sensor (Thermistor FP07, 12 ms response time), an acceleration sensor and two tilt sensors, as well as conductivity, temperature, pressure sensors that sample at a lower frequency (24 Hz). In addition, oxygen and turbidity sensors were attached. The profiler was optimized to sink at a rate of about 0.6 m/s which minimizes uncertainties in microstructure shear measurements.

In total, microstructure measurements were performed on 38 stations. Routinely, at least 3 profiles were collected on individual stations before or after CTD casts. In addition, four stations of 3-hour duration contributed about 10 profiles each, and during a 24 hour station, 38 profiles were collected at a single location (see Table A4.5). While most of the profiles were terminated in a depth of about 250 m, measurements within the oxygen minimum were extend to a depth up to 350 m to include the upper boundary of the oxygen minimum zone. Three shear probes (S/N 6070, 6071, 003) were used. Sensor 6070 lost its sensitivity after the first three MSS stations. It was replaced by sensor 003. After station 11 a failure of the cable led to a termination of the data transmission to the deck unit. This was due to a short circuit due to a leakage in the cable at the connection to the profiler. The error was removed by shortening the Kevlar cable by 20m. No further problems aroused during the cruise.

Preliminary Results

In general there are several regions and situations, where elevated levels of turbulence and thus diapycnal mixing is expected. Within the mixed layer, levels of turbulence are usually high due to the influence of winds and night time cooling at the ocean surface. Mixing below this well mixed layer is less likely to occur and depends on the interaction of several parameters. The measurement program aims at a better understanding of these interactions and at quantifying the influence of individual parameters on integral diapycnal fluxes of ocean properties.

The situations in which high levels of turbulence are more likely to occur in deeper layers are regions, in which background shear is elevated in respect to stratification. There, the flow may then become unstable in a Kelvin-Helmholtz sense and energy from the mean flow is fed into the turbulent regime. Near the equator, background shear levels are particularly pronounced in the region of the Equatorial Undercurrent, where zonal velocity shows the strong core at about 50 m depth (Fig. 4.21a). Here, shear levels are most elevated above the core of the EUC between 30 and 50 m. Accordingly, dissipation rates of turbulent kinetic energy that were derived from the microstructure measurements indicate elevated turbulence levels in the same region (Fig. 4.21e). These elevated levels however, that are in the range of $1\text{-}10\times10^{-8}$ Wkg^{-1}, are at the lower end of previously observed dissipation rates above the EUC core. Microstructure measurements in the EUC region at 10°W during September 2005 indicated strongly elevated dissipation rates of $1\text{-}3\times10^{-6}$ Wkg^{-1} during turbulent bursts occurring at night in the stratified region above the EUC core. These bursts were absent during a second microstructure measurement program carried out in December 1994, where similar levels of turbulence as found during the R/V L'ATALANTE cruise were observed. It could be shown that stronger stratification above the EUC core during the December 1994 cruise compared to the September 2005 cruise prevented the occurrence of

Kelvin-Helmholtz Instability in a large part of the water column and thus inhibited significant energy transfer from the background flow to the turbulent regime. The same argument could also hold here, as stratification encountered above the EUC during the R/V L'ATALANTE cruise was also pronounced above the EUC core (Fig. 4.21d).

Another possible source for bands of enhanced large scale shear are highly-baroclinic internal waves which are marked by changing velocities with depth. In some occasions, bands of elevated shear in the deeper water column may provide information about the nature of the propagating internal wave signal. However, due to the coarse vertical resolution of the shipboard ADCP, having an effective vertical resolution for shear of 16 m, together with the short duration of the CTD/microstructure stations make it hard to identify the propagation of internal waves. Nevertheless, wave-like structures in the upper ocean shear distribution (Fig. 4.21c) were pronounced in the some regions along the 23°W section (e.g. at 7°N) suggesting wind induced inertial gravity waves, which in turn may lead to locally elevated patches of turbulent dissipation rates.

As mentioned above, dissipation rates are usually elevated in the mixed layer, but also depend on the time within the day. Night-time convection in the mixed layer sets in when the heat loss exceeds the heat gain at the ocean surface, and results in weakening of the stratification. If the stratification is weak wind induced mixing can penetrate deeper into the surface layers. Most measurements on the section were not collected in the early morning hours leading to mixing being confined to the upper part of the surface mixed layer. However, some measurements were taken during early morning hours marked by higher mixing rates and rather weak stratification extending until about 50m depth (e.g. at 8°N) originated from night time convection.

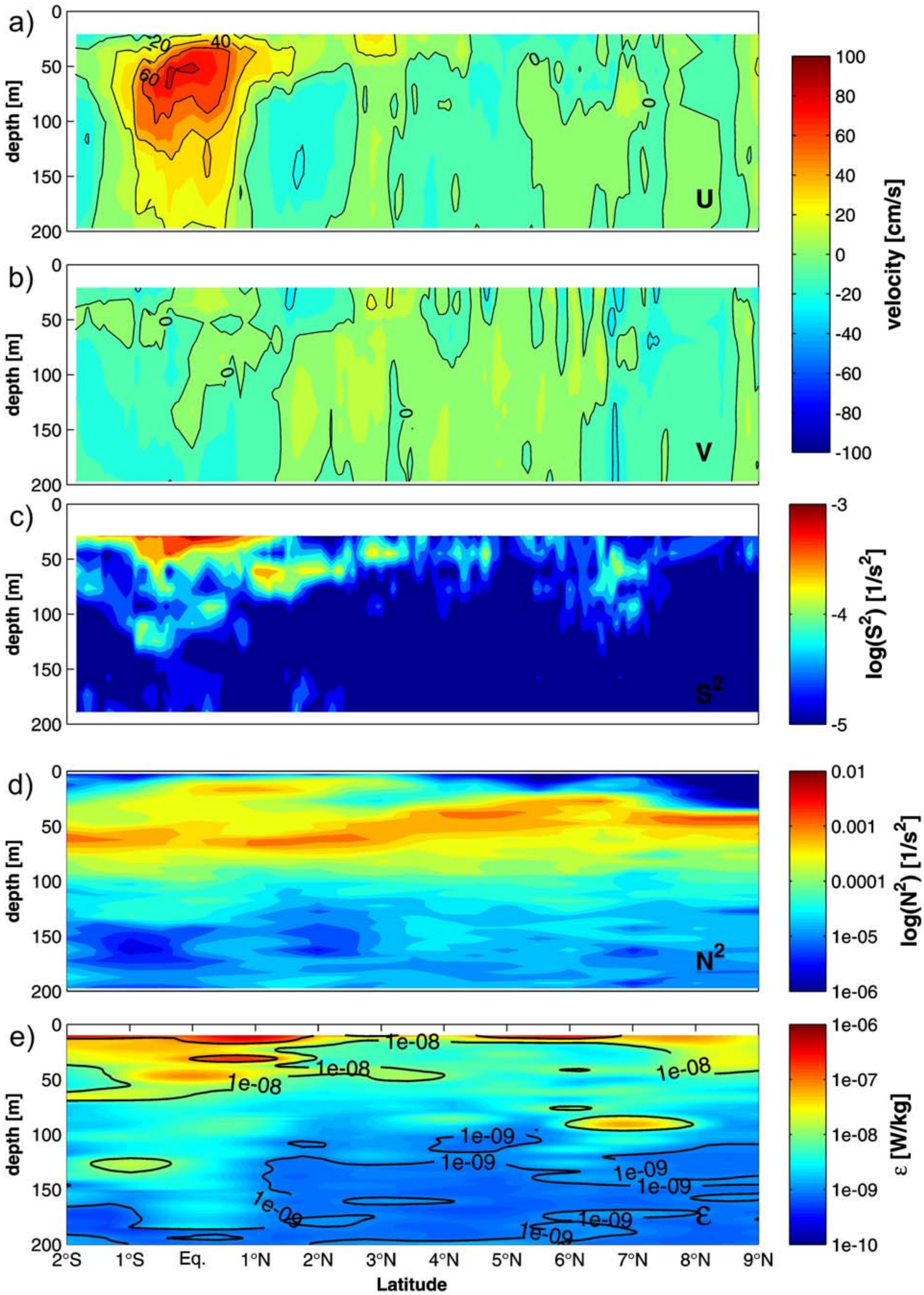


Fig. 4.21: Section at 23°W of a) zonal velocity, b) meridional velocity, c) total squared shear. d) Brunt-Vaisala frequency, e) dissipation rate of turbulent kinetic energy.

4.4.6 Chemical Measurements

Oxygen

Oxygen samples were analyzed by standard Winkler-titration. For the standardization of the thiosulphate solution an iodate standard was used. Samples were taken in 100 mL glass bottles with glass stoppers. After slow filling (avoiding bubbling and turbulence), sufficient overflow must be ensured: two to three times the content of the bottle. Then 1 mL of $MnCl_2$ and 1 mL of alkaline iodide were added simultaneously with a special dispenser. The stopper was then inserted and the bottles were shaken for about 1 minute to bring each molecule of dissolved oxygen into contact with manganese (II) hydroxide. After fixation of the oxygen, the precipitate was allowed to settle for minimum half an hour, before starting the titration.

Oxygen was analyzed from 801 Niskin bottles at 51 CTD-Stations according to a standard titration after Winkler (Grashoff, 1999). Two duplicate samples were taken and analyzed at all 51 stations, and the precision of the measurement was determined as 0.3 µmol kg^{-1} (95 % confidence interval).

Nutrients

Nutrients (nitrate, nitrite, phosphate, silicate) were determined from 656 water samples at 37 CTD-Stations. Samples were taken in 60 mL NALGENE PP bottles with screw caps. Bottles and caps were rinsed twice and then filled. The nutrient analysis was made with a Continuous-Flow-Autoanalyzer-(CFA) System developed and built at IFM-GEOMAR according to Grashoff et al. (1999). For the determination of phosphate, the method by Bran and Luebbe (Method No. G-175-96 Rev 8) was used.

The precision for nutrient analysis as determined from 75 double samples from 37 stations was determined as (95 % confidence interval): Nitrite 0.006 µmol kg^{-1}; Nitrate 0.13 µmol kg^{-1}; phosphate 0.008 µmol kg^{-1}, silicate 0.18 µmol kg^{-1}, which was approximately 1 % of the nutrient standards. Calibration curves were made with nutrients standards from Ocean Scientific International.

4.4.7 Thermosalinograph Measurements

Post-processing

Sea surface temperature (SST) and sea surface salinity (SSS) were measured by a Thermosalinograph mounted near the ship's seawater intake. The device was a SEACAT SBE 21 manufactured by Sea-Bird Electronics, Inc. and specifications are as follows:

	Measurement Range	Initial Accuracy	Resolution
Conductivity	0 to 7 S/m	0.001 S/m	0.0001 S/m
Temperature	-5 to +35 °C	0.01 °C	0.01

The Thermosalinograph worked well till the evening of March 9th when the temperature sensor showed an abrupt drop of about 0.4 °C. For this reason, temperature and salinity records were calibrated separately against CTD temperature and salinity data prior and after this occurrence. For the calibration CTD data acquired at 6 m depth were used. Constant offsets in

Thermosalinograph temperature and salinity were found to be adequate for calibration (Fig. 4.22) and while the derived values for temperature reflected the observed sudden decrease (-0.765 vs. -0.369 °C), no such difference was found for salinity (0.018 vs. 0.016 psu). The standard deviations of the temperature differences between the CTD and Thermosalinograph were quite large (0.031 and 0.040 °C) during the cruise, whereas low values of 0.015 and 0.010 psu were obtained for salinity. During post-processing, both Thermosalinograph data sets were corrected by removing the offsets and were submitted to the GOSUD/SISMER project, hosted at IFREMER in Brest, France (**http://www.ifremer.fr/sismer/program/gosud/**).

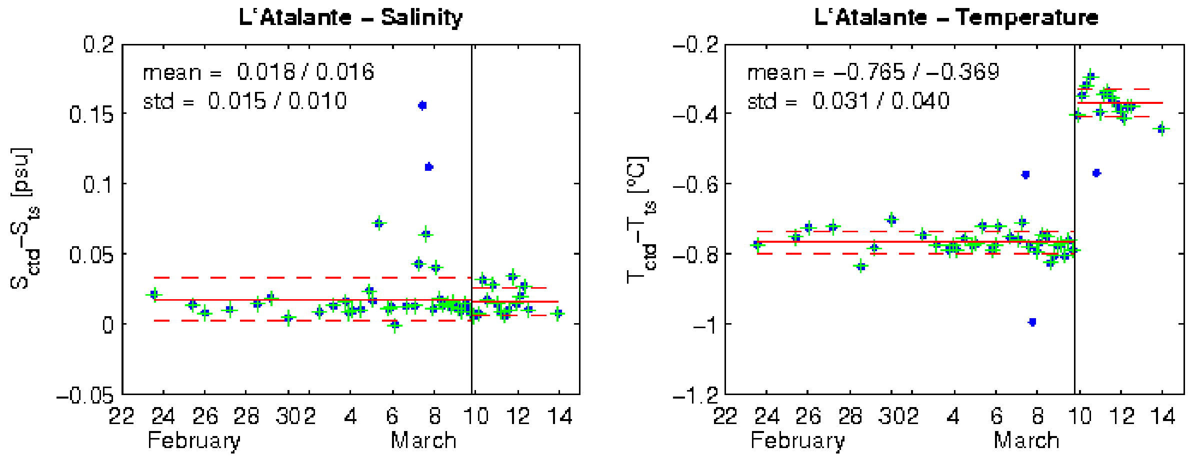


Fig. 4.22: Differences between CTD and thermosalinograph temperature (left panel) and salinity (right panel) versus time.

<u>Observations</u>

Fig. 4.23 shows the Thermosalinograph SST and SSS during the cruise, separated in the way from and back to Mindelo. While SSTs are generally increasing from Mindelo to about 6°N (~ 22 to 28 °C), SSSs are decreasing (~ 36.5 to 35.5 psu). South of this latitude, SSTs are around 28 °C but large SSS fluctuations can be observed.

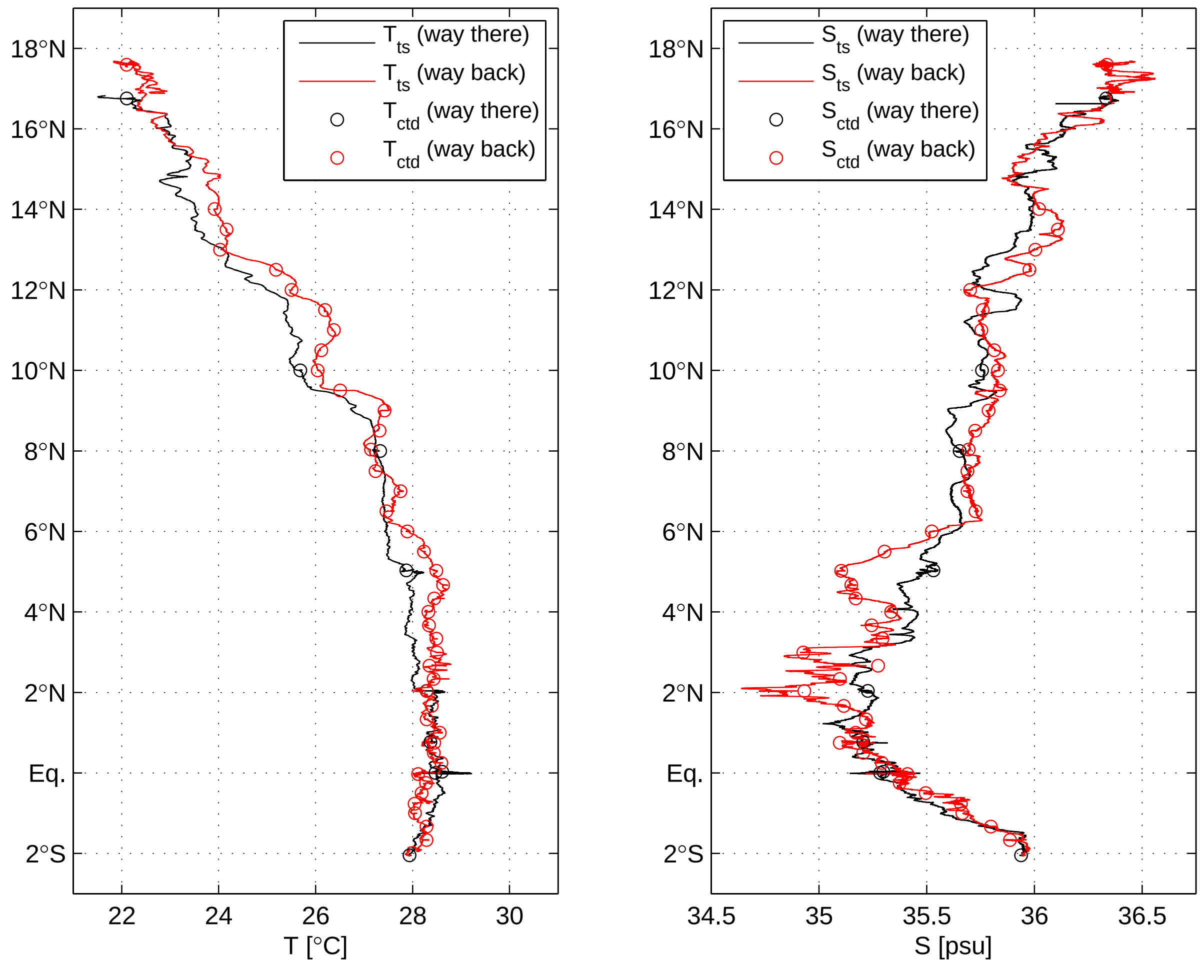


Fig. 4.23: Calibrated Thermosalinograph SST (left panel) and SSS (right panel), with respective CTD data.

4.4.8 Film coverage

Film coverage of research cruise IFM-GEOMAR 4 aboard the French R/V L'ATALANTE, between February 21, 2008 and March 17, 2008 was provided by Prof. Stephan Sachs and student assistant Michael Gülzow on behalf of the Muthesius Academy of Fine Arts. An agreement with IFREMER, the ship's owner, was negotiated and signed prior to the cruise by IFM-GEOMAR and Muthesius Academy of Fine Arts, both members of the Cluster of Excellence, "The Future Ocean".

The goal of the film accompaniment was not any journalistic coverage *per se* but a broad, artistic and documentary collection of materials. The intended purpose is manifold: As a member of the cluster's public outreach, Prof. Stephan Sachs collects moving images and sound bites from various areas of cluster-related activities to create a public image of the diverse, primarily scientific disciplines. In fact, a clear differentiation in terms of format and content from the customary television and documentary films is intended. Aside from the film activities themselves, the use of these materials is also scheduled for cluster-related exhibits (some of these have been successfully implemented in this constellation).

Furthermore, the images will be used for the participants' own personal artistic research which, as far as Stephan Sachs is concerned, investigates the interaction between the arts and natural sciences, among others.

All filming was done in HDV format. Depending on the task at hand, three different cameras, plus splash and underwater housings were used. Since diving itself was not permitted, certain gadgets had to be constructed for underwater filming. More spectacular events, such as filming the recovery and deployment of a glider from the ship's zodiac, were the exception rather than the rule.

The focus of our film activities were not any sensational events but the normality of basic research instead: deployment and recovery of moorings, lowering and retrieval of the CTD rosette, microstructure measurements, look-out for and tracking of drifting mooring elements, the submerging of a glider – all of these are strange, i.e. uncommon, and fascinating experiences. Rows and columns of data, plus diagrams, provide just a glance at the complexity of the underlying research.

The main focus was on the technical and scientific work, however, the special atmosphere of life aboard a research ship in equatorial latitudes was not short-changed.

The natural skepticism toward the nearly omnipresent camera quickly disappeared, and the camera work thus became just another one of the regular shipboard activities.

The collaboration with chief scientist and the science team, as well as the ship's master and crew, was very pleasant.

4.5 Acknowledgements

We very much appreciated the cooperative working atmosphere as well as the professionalism and seamanship of crew, officers and Captain of R/V L'ATALANTE, which made this work a success. Financial support came from the German Bundesministerium für Bildung, Wissenschaft und Forschung (BMBF) as part of the Verbundvorhaben Nordatlantik (Nordatlantik, 03F0443B) and from the German Science Foundation (DFG) as part of the SFB754 (Climate Biogeochemistry Interactions in the Tropical Ocean) and the EMMY NOETHER project (Diapycnal mixing processes in the upwelling regions of the tropical Atlantic, DE 13691-1).

Appendix

Table A4.1: CTD Stations

SHIP EXPOCODE	Station No.	3.1.1.1 No.	DATE Mmddyy	UTC TIME	CODE	POSITION LATITUDE			LONGITUDE			Uncorr. DEPTH	MAX PRESS	NO. OF BOTTLES	PAR.
08AT004	001	1	022308	1333	BE	16	45.15	N	25	06.19	W	1644		16	2, 3, 4
08AT004	001	1	022308	1401	BO	16	45.48	N	25	06.75	W	1644	1066	16	
08AT004	001	1	022308	1433	EN	16	45.71	N	25	06.75	W	1644		16	
08AT004	002	2	022508	0953	BE	10	00.10	N	22	59.92	W	5037		16	2, 3, 4
08AT004	002	2	022508	1029	BO	10	00.18	N	22	59.98	W	5039	1307	16	
08AT004	002	2	022508	1143	EN	10	10.38	N	22	59.88	W	5015		16	
08AT004	003	3	022508	0010	BE	07	59.98	N	22	59.97	W	4419		16	2, 3, 4
08AT004	003	3	022608	0210	BO	08	00.24	N	22	59.87	W	4428	4470	16	
08AT004	003	3	022608	0325	EN	08	00.33	N	22	59.78	W	4429		16	
08AT004	004	4	022708	0428	BE	05	01.87	N	22	59.98	W	4219		15	2, 3, 4
08AT004	004	4	022708	0501	BO	05	01.88	N	22	59.95	W	4220	1301	15	
08AT004	004	4	022708	0604	EN	05	01.83	N	23	00.65	W	4221		15	
08AT004	005	5	022808	1226	BE	02	02.50	N	23	01.99	W	4374		16	1, 2, 3, 4
08AT004	005	5	022808	1408	BO	02	02.48	N	23	01.99	W	4375	4419	16	
08AT004	005	5	022808	1606	EN	02	02.49	N	23	02.01	W	4378		16	
08AT004	006	6	022908	0401	BE	00	46.05	N	22	59.59	W	4327		16	1, 2, 3, 4
08AT004	006	6	022908	0432	BO	00	46.04	N	22	59.62	W	4327	1316	16	
08AT004	006	6	022908	0501	EN	00	46.04	N	22	59.62	W	4325		16	
08AT004	007	7	030108	0008	BE	00	01.96	N	22	58.39	W	3847		16	1, 2, 3, 4
08AT004	007	7	030108	0123	BO	00	02.19	N	22	58.22	W	3826	3867	16	
08AT004	007	7	030108	0235	EN	00	02.30	N	22	58.03	W	3820		16	
08AT004	008	8	030208	1209	BE	00	00.13	N	21	26.71	W	4961		16	1, 2, 3, 4
08AT004	008	8	030208	1240	BO	00	00.33	N	21	26.53	W	4959	1305	16	
08AT004	008	8	030208	1317	EN	00	00.56	N	21	26.18	W	4958		16	
08AT004	009	9	030308	0337	BE	02	02.65	S	23	04.93	W	5053		16	1, 2, 3, 4
08AT004	009	9	030308	0532	BO	02	02.93	S	23	04.83	W	5069	5112	16	
08AT004	009	9	030308	0706	EN	02	02.75	S	23	04.06	W	5098		16	
08AT004	010	10	030308	1753	BE	01	40.02	S	23	00.09	W	4934		16	1, 2, 3, 4
08AT004	010	10	030308	1843	BO	01	39.83	S	22	59.92	W	4923	1304	16	
08AT004	010	10	030308	1938	EN	01	39.47	S	22	59.41	W	4989		16	
08AT004	011	11	030308	2154	BE	01	20.01	S	22	59.95	W	4860		16	1, 2, 3, 4
08AT004	011	11	030308	2222	BO	01	19.92	S	22	59.88	W	4854	1316	16	
08AT004	011	11	030308	2252	EN	01	19.73	S	22	59.63	W	4826		16	
08AT004	012	12	030408	0203	BE	00	59.98	S	23	00.03	W	4122		16	1, 2, 3, 4
08AT004	012	12	030408	0232	BO	00	00.01	S	22	59.99	W	4118	1318	16	
08AT004	012	12	030408	0304	EN	01	00.04	S	22	59.87	W	4129		16	
08AT004	013	13	030408	1132	BE	00	45.82	S	22	57.33	W			16	1, 2, 3, 4
08AT004	013	13	030408	1200	BO	00	45.64	S	22	57.13	W		1307	16	
08AT004	013	13	030408	1227	EN	00	45.44	S	22	56.95	W			16	

SHIP	**Station**	**3.1.1.2**	**DATE**	**UTC**		**POSITION**						**Uncorr.**	**MAX**	**NO. OF**	
EXPOCODE	**No.**	**No.**	**Mmddyy**	**TIME**	**CODE**	**LATITUDE**			**LONGITUDE**			**DEPTH**	**PRESS**	**BOTTLES**	**PAR.**
08AT004	014	14	030408	2114	BE	00	30.08	S	23	00.13	W	4625		16	1, 2, 3, 4
08AT004	014	14	030408	2144	BO	00	30.02	S	22	59.98	W	4627	1314	16	
08AT004	014	14	030408	2213	EN	00	30.07	S	22	59.69	W	4630		16	
08AT004	015	15	030508	0105	BE	00	15.01	S	23	00.01	W	4162		16	1, 2, 3, 4
08AT004	015	15	030508	0143	BO	00	14.97	S	22	59.84	W	4123	1315	16	
08AT004	015	15	030508	0216	EN	00	15.03	S	22	59.59	W	4107		16	
08AT004	016	16	030508	0833	BE	00	01.44	S	23	06.54	W	3943		16	1, 2, 3, 4
08AT004	016	16	030508	0948	BO	00	01.04	S	23	06.03	W	3942	3988	16	
08AT004	016	16	030508	1105	EN	00	00.41	S	23	05.59	W			16	
08AT004	017	17	030508	1935	BE	00	14.98	N	23	00.10	W			16	1, 2, 3, 4
08AT004	017	17	030508	2006	BO	00	15.20	N	22	59.78	W		1315	16	
08AT004	017	17	030508	2035	EN	00	15.39	N	22	59.43	W			16	
08AT004	018	18	030508	2304	BE	00	30.07	N	22	59.95	W			16	1, 2, 3, 4
08AT004	018	18	030508	2335	BO	00	30.41	N	22	59.63	W		1314	16	
08AT004	018	18	030608	0001	EN	00	30.59	N	22	59.46	W			16	
08AT004	019	19	030608	0250	BE	00	45.03	N	23	01.51	W			16	1, 2, 3, 4
08AT004	019	19	030608	0319	BO	00	45.09	N	23	01.39	W		1304	16	
08AT004	019	19	030608	0349	EN	00	45.10	N	23	01.19	W			16	
08AT004	020	20	030608	1604	BE	00	59.98	N	23	00.03	W	3229		16	1, 2, 3, 4
08AT004	020	20	030608	1632	BO	01	00.04	N	22	59.98	W	3228	1302	16	
08AT004	020	20	030608	1738	EN	01	00.07	N	22	59.76	W				
08AT004	021	21	030708	0159	BE	01	20.01	N	22	59.98	W	4721		16	1, 2, 3, 4
08AT004	021	21	030708	0229	BO	01	19.96	N	22	59.84	W	4722	1302	16	
08AT004	021	21	030708	0256	EN	01	19.94	N	22	59.77	W	4726		16	
08AT004	022	22	030708	0603	BE	01	39.99	N	23	00.07	W	4130		16	3, 4, 7, 8
08AT004	022	22	030708	0634	BO	01	40.0	N	23	00.07	W	4128	1302	16	
08AT004	022	22	030708	0700	EN	01	40.07	N	23	00.01	W	4129		16	
08AT004	023	23	030708	1018	BE	02	02.05	N	23	01.05	W	4356		16	1, 2, 3, 4
08AT004	023	23	030708	1046	BO	02	02.16	N	23	00.85	W	4357	1311	16	
08AT004	023	23	030708	1111	EN	02	02.22	N	23	00.65	W	4362		16	
08AT004	024	24	030708	1413	BE	02	20.02	N	22	59.98	W	4283		16	1, 2, 4
08AT004	024	24	030708	1444	BO	02	20.04	N	23	00.06	W	4271	1302	16	
08AT004	024	24	030708	1553	EN	02	20.13	N	23	00.08	W	4257		16	
08AT004	025	25	030708	1801	BE	02	39.94	N	22	59.88	W	4728		16	1, 2, 3, 4
08AT004	025	25	030708	1832	BO	02	40.02	N	22	59.85	W	4696	1305	16	
08AT004	025	25	030708	1932	EN	02	40.12	N	22	59.88	W	4696		16	
08AT004	026	26	030708	2245	BE	02	59.62	N	22	59.95	W	4647		16	2, 4
08AT004	026	26	030708	2312	BO	02	59.73	N	23	00.06	W	4650	1315	16	
08AT004	026	26	030708	2338	EN	02	59.84	N	23	00.22	W	4654		16	
08AT004	027	27	030808	0157	BE	03	19.98	N	23	00.00	W	4161		16	2, 3, 4
08AT004	027	27	030808	0226	BO	03	20.00	N	23	00.00	W	4160	1306	16	
08AT004	027	27	030808	0250	EN	03	20.01	N	22	59.98	W	4161		16	

SHIP	Station	3.1.1.3	DATE	UTC		POSITION							Uncorr.	MAX	NO. OF	
EXPOCODE	No.	No.	Mmddyy	TIME	CODE	LATITUDE			LONGITUDE				DEPTH	PRESS	BOTTLES	PAR.
08AT004	028	28	030808	0603	BE	03	39.97	N	22	59.98	W		4434		16	2, 4
08AT004	028	28	030808	0635	BO	03	40.06	N	23	00.13	W		4428	1303	16	
08AT004	028	28	030808	0711	EN	03	40.15	N	23	00.33	W		4421		16	
08AT004	029	29	030808	1030	BE	03	59.95	N	22	59.97	W		4221		16	2, 3, 4
08AT004	029	29	030808	1059	BO	04	00.14	N	23	00.06	W		4219	1302	16	
08AT004	029	29	030808	1157	EN	04	00.63	N	23	00.13	W		4219		16	
08AT004	030	30	030808	1458	BE	04	19.94	N	22	59.98	W		4250		16	2, 4
08AT004	030	30	030808	1528	BO	04	19.96	N	23	00.00	W		4249	1302	16	
08AT004	030	30	030808	1634	EN	04	20.17	N	23	00.02	W		4262		16	
08AT004	031	31	030808	1851	BE	04	39.94	N	23	00.04	W		4220		16	2, 3, 4
08AT004	031	31	030808	1920	BO	04	39.88	N	23	00.03	W			1303	16	
08AT004	031	31	030808	1948	EN	04	40.02	N	23	00.22	W		4222		16	
08AT004	032	32	030808	2209	BE	05	01.12	N	22	59.44	W		4213		16	2, 4
08AT004	032	32	030808	2235	BO	05	01.26	N	22	59.44	W		4213	1307	16	
08AT004	032	32	030808	2301	EN	05	01.49	N	22	59.40	W		4211		16	
08AT004	033	33	030908	0259	BE	05	29.97	N	22	59.98	W		4235		16	2, 3, 4
08AT004	033	33	030908	0330	BO	05	30.07	N	23	00.01	W		4231	1301	16	
08AT004	033	33	030908	0356	EN	05	30.12	N	22	59.95	W		4236		16	
08AT004	034	34	030908	0705	BE	05	59.98	N	23	00.04	W		4095		16	2, 4
08AT004	034	34	030908	0733	BO	06	00.11	N	23	00.24	W		4094	1305	16	
08AT004	034	34	030908	0759	EN	06	00.15	N	23	00.38	W		4091		16	
08AT004	035	35	030908	1149	BE	06	29.98	N	22	59.95	W		3135		16	2, 3, 4
08AT004	035	35	030908	1216	BO	06	3026	N	23	00.03	W		3229	1299	16	
08AT004	035	35	030908	1317	EN	06	30.06	N	23	00.13	W		3107		16	
08AT004	036	36	030908	1640	BE	06	59.95	N	23	00.00	W		1497		16	2, 4,
08AT004	036	36	030908	1707	BO	06	59.97	N	23	00.00	W		1475	1309	16	
08AT004	036	36	030908	1736	EN	07	00.08	N	23	00.04	W		1454		16	
08AT004	037	37	030908	2144	BE	07	29.88	N	22	59.95	W		4392		16	2, 3, 4
08AT004	037	37	030908	2213	BO	07	30.07	N	22	59.95	W		4392	1315	16	
08AT004	037	37	030908	2239	EN	07	30.20	N	23	00.05	W		4392		16	
08AT004	038	38	031008	0305	BE	08	02.14	N	22	59.99	W		4493		16	2, 4
08AT004	038	38	031008	0334	BO	08	02.11	N	22	59.00	W		4488	1301	16	
08AT004	038	38	031008	0400	EN	08	02.16	N	22	59.07	W		4490		16	
08AT004	039	39	031008	0758	BE	08	29.98	N	23	00.03	W		4783		16	2, 3, 4
08AT004	039	39	031008	0829	BO	08	30.02	N	23	00.01	W		4783	1303	16	
08AT004	039	39	031008	0854	EN	08	30.12	N	23	00.01	W		4783		16	
08AT004	040	40	031008	1319	BE	09	00.00	N	23	00.01	W		4893		16	2, 4
08AT004	040	40	031008	1349	BO	09	00.00	N	22	59.98	W		4897	1302	16	
08AT004	040	40	031008	1455	EN	08	59.98	N	22	59.99	W		4892		16	
08AT004	041	41	031008	1934	BE	09	29.95	N	22	59.98	W		4637		16	2, 3, 4
08AT004	041	41	031008	2000	BO	09	30.04	N	22	59.93	W		4637	1312	16	
08AT004	041	41	031008	2027	EN	09	30.06	N	23	00.01	W		4630		16	

SHIP	Station	3.1.1.4	DATE	UTC		POSITION						Uncorr.	MAX	NO. OF	
EXPOCODE	No.	No.	Mmddyy	TIME	CODE	LATITUDE			LONGITUDE			DEPTH	PRESS	BOTTLES	PAR.
08AT004	042	42	031108	0002	BE	09	59.92	N	22	59.98	W	5045		16	2, 4
08AT004	042	42	031108	0031	BO	10	00.10	N	22	59.92	W	5032	1314	16	
08AT004	042	42	031108	0059	EN	10	00.26	N	22	59.92	W	5009		16	
08AT004	043	43	031108	0434	BE	10	30.00	N	23	0006..	W	5191		16	2, 3, 4
08AT004	043	43	031108	0505	BO	10	30.05	N	23	00.04	W	5186	1303	16	
08AT004	043	43	031108	0530	EN	10	30.12	N	22	59.97	W	5184		16	
08AT004	044	44	031108	0908	BE	11	00.01	N	23	00.00	W	5151		16	2, 4
08AT004	044	44	031108	0937	BO	11	00.38	N	23	00.05	W	5149	1305	16	
08AT004	044	44	031108	1003	EN	11	00.66	N	23	00.15	W	5147		16	
08AT004	045	45	031108	1357	BE	11	29.98	N	23	00.01	W	5112		16	2, 3, 4
08AT004	045	45	031108	1426	BO	11	30.14	N	23	00.00	W	5112	1302	16	
08AT004	045	45	031108	1451	EN	11	30.26	N	23	00.04	W	5112		16	
08AT004	046	46	031108	1828	BE	11	59.98	N	22	59.98	W	5044		16	2, 4
08AT004	046	46	031108	1858	BO	12	00.10	N	22	59.89	W	5044	1303	16	
08AT004	046	46	031108	1922	EN	12	00.20	N	22	59.80	W	5045		16	
08AT004	047	47	031108	2303	BE	12	29.91	N	22	59.95	W	4921		16	2, 3, 4
08AT004	047	47	031108	2331	BO	12	30.13	N	22	59.89	W	4919	1305	16	
08AT004	047	47	031108	2358	EN	12	30.43	N	22	59.79	W	4916		16	
08AT004	048	48	031208	0328	BE	12	59.94	N	23	00.03	W	4740		16	2, 4
08AT004	048	48	031208	0357	BO	13	00.08	N	22	59.92	W	4741	1303	16	
08AT004	048	48	031208	0422	EN	13	00.19	N	22	59.81	W	4739		16	
08AT004	049	49	031208	0748	BE	13	29.89	N	23	00.06	W	4540		16	2, 3, 4
08AT004	049	49	031208	0821	BO	13	30.12	N	22	59.88	W	4536	1303	16	
08AT004	049	49	031208	0848	EN	13	30.24	N	22	59.81	W	4538		16	
08AT004	050	50	031208	1236	BE	14	00.31	N	22	59.98	W	4317		16	2, 4
08AT004	050	50	031208	1304	BO	14	00.55	N	23	00.05	W	4317	1302	16	
08AT004	050	50	031208	1330	EN	14	00.78	N	23	00.08	W	4314		16	
08AT004	051	51	031308	2240	BE	17	35.43	N	24	15.12	W	3595		21	
08AT004	051	51	031308	2347	BO	17	35.04	N	24	15.48	W	3598	3636	21	2, 3
08AT004	051	51	031408	0055	EN	17	36.45	N	24	15.82	W	3606		21	

Code: BE = begin, BO = bottom, EN = end

Parameters (Par.):, 1=He, 2=Oxy, 3=Nuts, 4=Sal

Table A4.2: Calibration coefficients for the different optodes.

Optode S/N	Cal Date	Deployment Location/Platform		Temperature (°C) Slope	Bias	rms
349	Mar-08	KPO_1006	127m	0.99816	0.02436	0.028
688	Mar-08	KPO_1001	Profiler	0.99675	0.05808	0.019
691	Mar-08	Glider	ifm03	0.99743	0.04524	0.027
937	Mar-08	Pirata		0.99088	0.09257	0.113
938	Mar-08	Pirata		0.99178	0.08532	0.077
939	Mar-08	KPO_1023	306m	0.98556	0.14252	0.173
940	Mar-08	Pirata		0.98653	0.12672	0.170
941	Mar-08	KPO_1026	77m	0.98572	0.13294	0.181
942	Mar-08	KPO_1023	501m	0.98970	0.09986	0.143
944	Mar-08	KPO_1025	385m	0.99015	0.08868	0.092
945	Mar-08	KPO_1025	495m	0.98488	0.14418	0.163
946	Mar-08	Pirata		0.99113	0.09395	0.093
943	Apr-08	Pirata		0.99951	0.02200	0.007
839	Apr-08	Glider	ifm02	0.99991	0.01574	0.010

Optode S/N	Oxygen (µmol / kg) Bias	A(O)	A(O**2)	A(t)	A(p)	rms
349	-1.245	1.1792	-3.720E-04	2.800E-02	5.758E-03	0.323
688	-5.746	1.2348	-3.644E-04	1.705E-01	6.950E-03	0.293
691	-18.426	1.1785	-3.142E-04	5.462E-01	6.083E-03	0.351
937	45.771	0.951	6.052E-04	-2.209E+00	-2.052E-02	0.484
938	53.680	0.931	7.490E-04	-2.720E+00	-2.751E-02	0.748
939	28.366	0.974	4.879E-04	-1.333E+00	-1.563E-02	0.529
940	49.229	0.929	7.266E-04	-2.461E+00	-2.363E-02	0.581
941	53.571	0.914	8.073E-04	-2.754E+00	-2.591E-02	0.571
942	50.091	0.944	6.780E-04	-2.478E+00	-2.320E-02	0.579
944	68.165	0.906	9.996E-04	-3.716E+00	-3.736E-02	1.382
945	53.246	0.911	8.279E-04	-2.702E+00	-2.670E-02	0.542
946	48.823	0.936	6.908E-04	-2.451E+00	-2.186E-02	0.515
943	147.960	0.389	6.180E-03	-7.946E+00	-8.864E-02	0.000
839	0.000	1.248	-8.849E-05	7.569E-01	2.517E-02	0.000

Table A4.3: Calibration coefficients for Microcats and MTD Logger

CTD No.	S/N	Temperature Bias	Temperature Slope	Temperature RMS	Conductivity Bias	Conductivity Slope	Conductivity RMS	Pressure Bias	Pressure Slope	Pressure RMS
1	2245	0.004911	0.998937	0.012	-.023994	1.000162	0.011			
1	2247	0.004947	0.999078	0.011	-0.055289	1.001080	0.012			
1	2248	0.003766	0.998999	0.012	-0.000530	0.999448	0.011			
2	3196	0.008469	0.998214	0.013	0.034991	0.998588	0.009			
4	53	-0.003237	0.999920	0.007	-0.021154	1.000142	0.011			
4	1269	0.000111	0.999252	0.011	-0.170789	1.004694	0.026			
4	1284	0.000637	0.999300	0.011	-0.172329	1.005047	0.024			
4	1286	-0.000276	0.999322	0.010	-0.170304	1.004671	0.024			
4	2250	0.002997	0.998878	0.012	0.013979	0.997658	0.014			
4	3144	0.002068	0.999017	0.011	-0.000707	0.999503	0.013			
5	1320	0.000663	0.999191	0.013	-0.034962	1.001357	0.025			
5	2249	0.001262	0.999005	0.015	0.025490	0.998195	0.013			
5	2251	0.000946	0.999071	0.015	0.026441	0.998598	0.014			
20	1723	0.008747	0.997897	0.021	-0.014345	0.999530	0.020			
20	2262	0.008516	0.997957	0.021	-0.005466	0.999579	0.020	1.605862	1.001700	0.295
20	2488	0.007380	0.998181	0.022	-0.007331	1.000148	0.020	1.588798	1.000768	0.541
20	3411	0.008690	0.998016	0.022	-0.029081	0.999708	0.024	1.316540	1.002815	0.385
20	3415	0.008521	0.997876	0.020	-0.051253	1.000956	0.027	1.441111	1.002220	0.498
20	3755	0.009967	0.997919	0.021	-0.025978	0.999450	0.022	1.283954	0.998873	0.365
24	2718	-0.006062	1.000384	0.025	-0.047725	1.000955	0.030	-0.235581	1.002688	0.413
24	1550	-0.004278	0.999749	0.025	-0.030215	1.000341	0.027			
24	1682	-0.005485	0.999813	0.024	-0.026442	1.000165	0.026			
24	2468	-0.002495	0.999897	0.022	-0.014239	1.000012	0.026			
24	2472	-0.003592	1.000136	0.025	-0.012015	0.999527	0.029			
24	2618	-0.006761	1.000462	0.025	-0.029201	1.000327	0.029			
25	1162	0.000821	0.999275	0.013	-0.040287	1.000003	0.010			
25	1268	-0.001834	0.999504	0.013	-0.254478	1.007531	0.033			
25	2279	0.000388	0.999255	0.014	-0.003304	1.000010	0.011			
25	2617	0.002528	0.999230	0.014	0.000494	0.999600	0.011			

CTD No.	S/N	Temperature Bias	Temperature Slope	Temperature RMS	Conductivity Bias	Conductivity Slope	Conductivity RMS	Pressure Bias	Pressure Slope	Pressure RMS
29	2254	-0.001425	0.999531	0.010	-0.047930	1.001028	0.016			
29	2257	-0.001622	0.999565	0.010	-0.050548	1.000494	0.014			
29	2933	-0.002023	0.999559	0.009	-0.092354	1.002212	0.020			
29	24	0.088106	0.999515	0.019	MiniTD			3.267423	0.997745	0.654
29	26	-0.090633	1.000866	0.014	MiniTD			15.098628	1.009004	3.477
30	2252	-0.001873	0.999286	0.020	-0.042792	1.000477	0.019			
30	2255	-0.000544	0.999318	0.020	-0.053731	1.000985	0.019			
30	3752	-0.000441	0.999493	0.014	-0.090715	1.000949	0.019	2.315372	1.001572	0.346
30	3753	0.001113	0.999524	0.015	-0.073271	1.000087	0.016	2.607432	1.001131	0.349
30	3757	-0.000749	0.999561	0.015	-0.086916	1.001883	0.018	-0.413203	1.003270	0.498

CTD No.	S/N	Temperature Bias	Temperature Slope	Temperature RMS	Conductivity Bias	Conductivity Slope	Conductivity RMS	Pressure Bias	Pressure Slope	Pressure RMS
35	3754	0.006626	0.998641	0.015	0.008818	0.998980	0.012	0.765704	1.000394	0.520
35	52	0.001956	0.999758	0.013	-0.062161	1.001668	0.011			
35	55	-0.001090	0.999883	0.013	-0.047535	1.001431	0.010			
35	278	-0.003546	1.000110	0.017	-0.244667	1.007412	0.026			
35	381	0.006351	0.999807	0.012	-0.337975	1.010176	0.030			
35	780	0.001791	0.999836	0.011	-0.350030	1.013055	0.035			
35	921	-0.000040	0.999924	0.010	-0.257379	1.007588	0.019			
35	2256	0.008486	0.998265	0.017	0.041119	0.998298	0.015			
40	922	-0.006065	1.000383	0.008	-0.174512	1.005103	0.027			
40	925	-0.006815	1.000520	0.008	-0.194128	1.006081	0.028			
40	936	-0.003843	1.000050	0.007	-0.160516	1.004714	0.025			
40	1281	-0.005014	1.000396	0.009	-0.250646	1.007043	0.021			
40	1282	-0.006009	1.000509	0.009	-0.171192	1.005412	0.026			
40	1583	-0.001413	1.000219	0.009	0.007603	0.999202	0.009			
40	1599	-0.001351	0.999701	0.007	0.007569	0.999685	0.007			

Table A4.4: Mooring Recoveries and Deployments

R/V L'ATALANTE IFM-GEOMAR - 4 Mooring Recoveries					
Mooring	**Latitude**	**Longitude**	**Deployment Date**	**Recovery Date**	**Watchdog Argos ID**
AO_01	0N 00.00	23W 06.80	19-Jun-06	1-Mar-08	11278
AO_02	0N 45.00	22W 59.50	20-Jun-06	29-Feb-08	15172
AO_03	0S 44.95	22W 59.71	17-Jun-06	4-Mar-08	15173
AO_04	0S 00.00	21W 29.60	21-Jun-06	2-Mar-08	2254
AO_05	5N 00.90	23W 00.00	3-Jul-06	27-Feb-08	5461
V440_1	17N 35.39	24W 15.12	8-Jul-06	19-Feb-08	5510
R/V L'ATALANTE IFM-GEOMAR - 4 Mooring Deployments					
Mooring	**Latitude**	**Longitude**	**Deployment Date**	**Recovery Date**	**Watchdog Argos ID**
23W 2S	1S 56.40	22W 57.00	3-Mar-08		7373
23W 0:45S	0S 44.94	22W 59.70	4-Mar-08		12620
23W 0N	0N 00.00	23W 06.80	1-Mar-08		108
23W 0:45N	0N 45.17	22W 59.28	6-Mar-08		11458
23W 2N	2N 02.50	23W 02.00	28-Feb-08		5481
23W 5N	5N 00.90	23W 00.05	27-Feb-08		2267
23W 8N	8N 01.00	22W 59.00	26-Feb-08		2255
Cape Verde					

Mooring recoveries

Mooring Recovery Equatorial Atlantic AO_01					**Notes:**		
Vessel:	Meteor						
Deployed:	June 19	2006	19:53				
Vessel:	Atalante						
Recovered:	March 1	2008	07:21				
Latitude:	0	0.001	S				
Longitude:	23	6.800	W				
Water depth:	3931	Mag Var:	-16.3				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos WD	11278		no signal received		
AO_01_01	126	ADCP WH up	508	x	good data		
AO_01_02	126	Mini-TD	24		good data		
AO_01_03	130	Microcat	52	x	good data		
AO_01_04	234	Microcat	55	x	good data		
AO_01_05	399	Microcat	278	x	good data		
AO_01_06	621	ADCP LR up	2395	x	good data		
AO_01_07	687	RCM-8	9930	x	good data		
AO_01_08	842	Argonaut	D182	x	good data		
AO_01_09	998	RCM-8	9964	x	bad data after 3/20/2007		
AO_01_10	2264	M-CTD MMP	120	x	good data initially, degrading with time		
	3573	Release	174	Code:	9337	**9339**	**A**
	3573	Release	110	Code:	E972	**E974**	**A**
					Interrogate	Release	Mode

Mooring Recovery Equatorial Atlantic AO_02					Notes:		
Vessel:	Meteor						
Deployed:	June 20	2006	15:25				
Vessel:	Atalante						
Recovered:	Feb 29	2008	07:19		Flotation above releases imploded		
Latitude:	0	45.000	N				
Longitude:	22	59.500	W				
Water depth:	4310	Mag Var:	-16.0				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos WD	15172				
AO_02_01	51	Mini-TD	26		good data, minimum depth 32m		
AO_02_02	87	Microcat	381	x	good data		
AO_02_03	138	Microcat	780	x	good data, numerous read errors		
AO_02_04	200	Microcat	921	x	good data, numerous read errors		
AO_02_05	301	ADCP 150 up	589	x	good data		
AO_02_06	301	Mini-TD	11		good data		
AO_02_07	397	RCM-8	9346	x	good data		
AO_02_08	552	RCM-8	9932	x	good data		
AO_02_09	697	RCM-8	5881	x	good data		
AO_02_10	851	Argonaut	D143	x	questionable data		
AO_02_11	1007	RCM-8	8412	x	good data		
	3632	Release	188	Code:	8181	**8182**	**B**
	3632	Release	189	Code:	8183	**8184**	**B**
					Interrogate	Release	Mode

Mooring Recovery Equatorial Atlantic AO_03				Notes:
Vessel:	Meteor			
Deployed:	June 17	2006	18:21	
Vessel:	Atalante			
Recovered:	March 4	2008	07:23	Fishing line entangled in top 100m
Latitude:	0	44.950	S	
Longitude:	22	59.710	W	
Water depth:	3700	Mag Var:	-16.5	

ID	Depth	Instr. type	s/n	Startup log			
		Argos WD	15173		no signal received		
AO_03_01	~~47~~	~~Mini-TD~~	~~22~~		instrument lost		
AO_03_02	83	Microcat	922	x	good data		
AO_03_03	144	Microcat	925	x	good data		
AO_03_04	205	Microcat	936	x	good data		
AO_03_05	307	ADCP 150 up	267	x	good data		
AO_03_06	307	Mini-TD	27		good data		
AO_03_07	403	RCM-8	9816	x	good data		
AO_03_08	558	RCM-8	9349	x	good data		
AO_03_09	702	RCM-8	9819	x	good data		
AO_03_10	857	Argonaut	D145	x	good data		
AO_03_11	1013	RCM-8	9820	x	good data		
	3132	Release	190	Code:	8185	**8186**	**B**
	3132	Release	220	Code:	9151	**9152**	**B**
					Interrogate	Release	Mode

Mooring Recovery Equatorial Atlantic AO_04					**Notes:**		
Vessel:	Meteor						
Deployed:	June 21	2006	18:00				
Vessel:	Atalante						
Recovered:	March 2	2008	07:18		Top Argos and MiniTD torn off		
Latitude:	0	0.000	S				
Longitude:	21	29.600	W				
Water depth:	4950	Mag Var:	-15.8				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		~~Argos WD~~	~~2254~~		lost, top torn off		
AO_04_01	~~48~~	~~Mini-TD~~	~~73~~		lost, top torn off		
AO_04_02	81	Microcat	1281	x	good data until July 2007		
AO_04_03	142	Microcat	1282	x	good data until July 2007		
AO_04_04	204	Microcat	1583	x	good data until July 2007		
AO_04_05	455	ADCP LR up	2627	x	good data		
AO_04_06	455	Mini-TD	61		good data		
AO_04_07	459	Microcat	1599	x	good data		
AO_04_08	553	RCM-8	10501	x	good data		
AO_04_09	708	RCM-8	11621	x	good data		
AO_04_10	852	RCM-8	9818	x	good data		
AO_04_11	1007	Argonaut	D184	x	good data		
	4291	Release	428	Code:	2457	**2459**	**B**
	4291	Release	635	Code:	3A95	**3A96**	**A**
					Interrogate	Release	Mode

Mooring Recovery Equatorial Atlantic AO_05					**Notes:**		
Vessel:	Meteor						
Deployed:	July 3	2006	11:36				
Vessel:	Atalante						
Recovered:	Feb 27	2008	07:33		Major entanglement with fishing line		
Latitude:	5	0.900	N		preventing profiler movement		
Longitude:	23	0.000	W				
Water depth:	4210	Mag Var:	-14.5				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos WD	5461		no signal received		
AO_05_01	57	ADCP LR dn	3173	x	good data		
AO_05_02	~~57~~	~~Mini-TD~~	~~62~~		flooded, no data		
AO_05_03	103	Microcat	1682	x	good data, tuna hit in Aug 2006		
AO_05_04	616	M-CTD MMP	11617	x	45d of data, long-line hit in Aug 2006		
AO_05_05	1044	Microcat	2478	x	good data, long-line hit in Aug 2006		
AO_05_06	1045	RCM-8	10779	x	good data		
	3513	Release	441	Code:	8A03	**8A04**	**B**
	3513	Release	633	Code:	3A91	**3A92**	**A**
					Interrogate	Release	Mode

Mooring Recovery Cape Verde V440-01					**Notes:**
Vessel:	Meteor				
Deployed:	July 8	2006	15:56		
Vessel:	Atalante				
Recovered:	Feb 19	2008	08:23		Fishing line between 400 and 500m
Latitude:	17	35.390	N		
Longitude:	24	15.120	W		
Water depth:	3601	Mag Var:	-11.2		
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**	
		Argos WD	5510		N/A
V440_1_01	40	Microcat	3753		good data w/press
V440_1_02	40	Fluorometer	269		data not read yet
V440_1_03	62	Microcat	3752		good data w/press
V440_1_04	81	Microcat	1162		good data
V440_1_05	103	ADCP WH up	1522	x	good data
V440_1_06	103	Microcat	3755		good data w/press
V440_1_07	127	RCM-11	325	x	
V440_1_08	127	Optode	349		
V440_1_09	129	Microcat	2252		good data
V440_1_10	200	RCM-8	10810	x	good data
V440_1_11	202	Microcat	2255		good data
V440_1_12	302	Microcat	3754		good data w/press
V440_1_13	400	Microcat	2256		good data
V440_1_14	500	Microcat	2254		good data

ID	Depth	Instr. type	s/n	Startup log			
V440_1_15	602	RCM-8	11622	x	good data, needs temp cal		
V440_1_16	603	Microcat	3415		good data	w/press	
V440_1_17	753	Microcat	2257		good data, 4-day gap in Apr 2007		
V440_1_18	899	Watchdog	2265		N/A		
V440_1_19	899	Watchdog	11307		N/A		
V440_1_20	900	RCM-8	11265	x	OK data, 3 gaps of 1 month each		
V440_1_21	902	Microcat	2279		good data		
V440_1_22	999	Sediment Trap	97150		sent to Kiel		
V440_1_23	1002	Microcat	3757		good data	w/press	
V440_1_24	1151	Microcat	1550		good data		
V440_1_25	1299	RCM-8	11267	x	good data, 1 gap of 20 days		
V440_1_26	1301	Microcat	1269		no data, not started prior to deployment		
V440_1_27	1498	Microcat	2717		good data	w/press	
V440_1_28	1749	Mini-TD	63		good data		
V440_1_29	2001	RCM-8	10818	x	good data		
V440_1_30	2003	Microcat	1268		good, data, numerous read errors		
V440_1_31	2249	Mini-TD	64		good data		
V440_1_32	2500	Microcat	2933		good data		
V440_1_33	2748	Mini-TD	65		good data		
V440_1_34	3003	RCM-8	10776	x	good data		
V440_1_35	3005	Microcat	2617		good data		
V440_1_36	3250	Mini-TD	72		good data		
V440_1_37	3511	Microcat	2618		good data		
V440_1_38	3563	Microcat	2472		good data		
	3565	Release	108	Code:	E962	**E964**	**A**
	3565	Release	821	Code:	4AA7	**4AA8**	**A**
					Interrogate	Release	Mode

Mooring deployments

Mooring Deployment Equatorial Atlantic 23W 2S					**Notes:**	**KPO_1021**
Vessel:	Atalante					
Deployed:	3-Mar	2008	14:09			
Vessel:						
Recovered:						
Latitude:	1	56.701	S			
Longitude:	22	56.653	W			
Water depth:	4840	Mag Var:				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**		
		Argos	7373			
KPO_1021_01	298	ADCP NB up	270			
KPO_1021_02	298	MiniTD	67			
KPO_1021_03	395	Argonaut	304			

ID	Depth	Instr. type	s/n	Startup log			
KPO_1021_04	549	RCM-8	10504				
KPO_1021_05	694	RCM-8	94				
KPO_1021_06	848	Argonaut	179				
KPO_1021_07	1003	RCM-8	10500				
	4232	Release	31	Code:	5037	**5039**	**A**
	4232	Release	121	Code:	6177	**6178**	**B**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic 23W 0:45S					**Notes:**	**KPO_1022**	
Vessel:	Atalante						
Deployed:	4-Mar	2008	18:43				
Vessel:							
Recovered:							
Latitude:	0	44.940	S				
Longitude:	22	59.700	W				
Water depth:	3670	Mag Var:					
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos	12620				
KPO_1022_01	62	MiniTD	58				
KPO_1022_02	96	Microcat	1269	**x**			
KPO_1022_03	144	Microcat	2250	**x**			
KPO_1022_04	295	MiniTD	46				
KPO_1022_05	553	ADCP LR up	2290	**x**			
KPO_1022_06	698	RCM-8	9933	**x**			
KPO_1022_07	853	Argonaut	329	**x**			
KPO_1022_08	997	RCM-8	9833	**x**			
	3117	Release	173	Code:	9332	**9334**	**A**
	3117	Release	174	Code:	9337	**9339**	**A**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic 23W 0:00N					**Notes:**	**KPO_1023**
Vessel:	Atalante					
Deployed:	1-Mar	2008	19:43			
Vessel:						
Recovered:						
Latitude:	0	0.000	N			
Longitude:	23	6.800	W			
Water depth:	3935	Mag Var:				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**		
		Argos	108			
KPO_1023_01	40	ADCP 1200 up	7279	**x**	Recovered 5-Mar 2008	
KPO_1023_02	198	ADCP up	8237	**x**		
KPO_1023_03	203	Microcat	1284	**x**		

ID	Depth	Instr. type	s/n	Startup log			
KPO_1023_04	305	Microcat	1286	x			
KPO_1023_05	306	O2 Logger	939				
KPO_1023_06	500	Microcat	1320	x			
KPO_1023_07	501	O2 Logger	942				
KPO_1023_08	703	ADCP LR up	1181	x			
KPO_1023_09	848	Argonaut	144	x			
KPO_1023_10	1003	RCM-8	6122	x			
	3322	Release	107	Code:	E957	**E959**	**A**
	3322	Release	435	Code:	1469=ARM	**1469+1455**	**B**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic 23W 0:45N				**Notes:**	**KPO_1024**		
Vessel:	Atalante						
Deployed:	6-Mar	2008	10:35				
Vessel:							
Recovered:							
Latitude:	0	45.170	N				
Longitude:	22	59.280	W				
Water depth:	4320	Mag Var:					
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos	11458				
KPO_1024_01	64	MiniTD	57				
KPO_1024_02	97	Microcat	2249	x			
KPO_1024_03	143	Microcat	2251	x			
KPO_1024_04	300	MiniTD	31				
KPO_1024_05	555	ADCP LR up	3173	x			
KPO_1024_06	700	RCM-8	10658	x			
KPO_1024_07	855	Argonaut	151	x			
KPO_1024_08	1009	RCM-8	9311	x			
	3642	Release	271	Code:	1405=ARM	**1404+1455**	**B**
	3642	Release	122	Code:	6170	**6179**	**B**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic 23W 2N				**Notes:**	**KPO_1025**
Vessel:	Atalante				
Deployed:	6-Mar	2008	10:35		
Vessel:					
Recovered:					
Latitude:	2	2.500	N		
Longitude:	23	2.000	W		
Water depth:	4363	Mag Var:			

ID	Depth	Instr. type	s/n	Startup log			
		Argos	5481				
KPO_1025_01	297	ADCP up	623	x			
KPO_1025_02	297	MiniTD	70				
KPO_1025_03	385	O2 Logger	944				
KPO_1025_04	386	Microcat	3144	x			
KPO_1025_05	394	Argonaut	294	x			
KPO_1025_06	495	O2 Logger	945				
KPO_1025_07	496	Microcat	53	x			
KPO_1025_08	549	RCM-8	12004	x			
KPO_1025_09	693	RCM-8	8365	x			
KPO_1025_10	848	Argonaut	299	x			
KPO_1025_11	1003	RCM-8	10659	x			
	3832	Release	95	Code:	0485	**0455**	**B**
	3832	Release	41	Code:	E847	**E849**	**B**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic 23W 5N					**Notes:**	**KPO_1026**	
Vessel:	Atalante						
Deployed:	27-Feb	2008	18:30				
Vessel:							
Recovered:							
Latitude:	5	0.900	N				
Longitude:	23	0.000	W				
Water depth:	4216	Mag Var:					
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos	2267				
KPO_1026_01	76	MiniTD	71				
KPO_1026_02	77	O2 Logger	941				
KPO_1026_03	80	Microcat	2247	x			
KPO_1026_04	594	M-CTD MMP	12201-1	x			
KPO_1026_05	1022	RCM-8	9345	x			
KPO_1026_06	1023	Microcat	3196	x			
	3513	Release	107	Code:	0495	**0455**	**B**
	3513	Release	350	Code:	C620	**C629**	**B**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic 23W 8N				**Notes:**	**KPO_1027**
Vessel:	Atalante				
Deployed:	26-Feb	2008	10:49		
Vessel:					
Recovered:					
Latitude:	8	1.000	N		
Longitude:	22	59.000	W		

Water depth:	4484	Mag Var:						
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**				
		Argos	2255					
KPO_1027_01	81	MiniTD	59					
KPO_1027_02	85	Microcat	2245	**x**				
KPO_1027_03	599	M-CTD MMP	12255-1	**x**				
KPO_1027_04	1027	RCM-8	9727	**x**				
KPO_1027_05	1028	Microcat	2248	**x**				
	3922	Release	351		Code:	C375	**C376**	**B**
	3922	Release	659		Code:	4901	**4902**	**A**
						Interrogate	Release	Mode

Mooring Deployment Cape Verde V440-02					**Notes:**	**KPO_1028**
Vessel:	Atalante					
Deployed:	14-Mar	2008	10:58			
Vessel:						
Recovered:						
Latitude:	17	36.400	N			
Longitude:	24	14.980	W			
Water depth:	3598	Mag Var:	-11.2			
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**		
		~~Argos WD~~	~~5511~~	**x**		Wire cut after top float resurfaced on 14-Mar-08
KPO_1028_01	~~42~~	~~Microcat~~	~~2488~~	**x**	w/ press	
KPO_1028_02	~~42~~	~~Fluorometer~~	~~268~~	**x**		
KPO_1028_03	57	Microcat	1268	**x**	w/ press	
KPO_1028_04	77	Microcat	1723	**x**		
KPO_1028_05	79	O2 NIOZ	A7			
KPO_1028_06	100	Microcat	1599	**x**	w/ press	
KPO_1028_07	103	ADCP WH up	1522	**x**		
KPO_1028_08	127	RCM-11	325	**x**		
KPO_1028_09	127	Optode	349	**x**		
KPO_1028_10	128	Microcat	1162	**x**		
KPO_1028_11	201	Microcat	1682	**x**		
KPO_1028_12	300	Microcat	3411	**x**	w/ press	
KPO_1028_13	301	RBR	10385	**x**		
KPO_1028_14	401	O2 NIOZ	A4			
KPO_1028_15	403	Microcat	2279	**x**		
KPO_1028_16	602	RCM-8	9322	**x**		
KPO_1028_17	603	Microcat	2262	**x**		
KPO_1028_18	852	Microcat	2478	**x**		
KPO_1028_19	1103	Microcat	1550	**x**		
KPO_1028_20	1295	Sediment Trap	900000	**x**		
KPO_1028_21	1329	RCM-8	10815	**x**		
KPO_1028_22	1403	Microcat	3755	**x**	w/ press	

ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
KPO_1028_23	1702	Microcat	2718	**x**	w/ press		
KPO_1028_24	1703	Mini-TD	42	**x**			
KPO_1028_25	2028	Microcat	3415	**x**	w/ press		
KPO_1028_26	2029	Mini-TD	26	**x**			
KPO_1028_27	2528	Microcat	2617	**x**	w/ press		
KPO_1028_28	2529	Mini-TD	24				
KPO_1028_29	3001	Microcat	2618	**x**			
KPO_1028_30	3002	Mini-TD	36	**x**			
KPO_1028_31	3468	Sediment Trap	11804-1	**x**			
KPO_1028_32	3503	RCM-8	10074	**x**			
KPO_1028_33	3504	Microcat	2472	**x**			
KPO_1028_34	3505	Mini-TD	34	**x**			
	3565	Release	270	Code:	1404=ARM	**1404+1455**	**B**
	3565	Release	28	Code:	5022	**5024**	**A**
					Interrogate	Release	Mode

Table A4.5: Microstructure Stations

MSS Station	MSS profile	CTD Cast	Date (UTC)	Time (UTC)	Latitude [°N]	Longitude [°W]	max. Pressure range	shear 1	shear 2
1	1-6	3	26/2/2008	3:36	8.0195	22.9932	344-499	6070	6071
2	7-9	4	27/2/2008	6:10	5.0348	23.0102	249-267	6070	6071
3	11-13	4	27/2/2008	12:18	5.0350	22.9910	227-243	6070	6071
4	14-16	6	29/2/2008	5:08	0.7701	22.9915	363-391	6070	6071
5	20-25	7	29/2/2008	21:31	-0.0129	22.9993	162-180	003	6071
6	26-30	7	1/3/2008	2:55	0.0415	22.9635	196-232	003	6071
7	31-35	7	1/3/2008	12:35	0.0013	23.0706	206-267	003	6071
8	36-38	11	3/3/2008	23:07	-1.3230	22.9869	207-227	003	6071
9	39-45	12	4/3/2008	3:13	-0.9903	22.9975	219-236	003	6071
10	46-51	13	4/3/2008	12:34	-0.7388	22.9391	153-158	003	6071
11	52-54	14	4/3/2008	22:22	-0.4997	22.9953	152-178	003	6071
12	55-57	15	5/3/2008	2:21	-0.2568	22.9911	186-208	003	6071
13	58-67	16	5/3/2008	4:54	-0.0616	23.0908	92-215	003	6071
14	68-78	16	5/3/2008	11:13	0.0383	23.0855	125-278	003	6071
15	79-81	17	5/3/2008	20:42	0.2688	22.9874	222	003	6071
16	82-84	18	6/3/2008	0:42	0.5749	22.9885	209-215	003	6071
17	85-87	19	6/3/2008	3:54	0.7713	23.0135	86-263	003	6071
18	89-91	20	6/3/2008	17:44	0.9991	22.9888	270-397	003	6071
19	92-94	21	7/3/2008	3:00	1.3444	22.9965	220-225	003	6071
20	95-97	22	7/3/2008	7:07	1.7051	22.9981	246-249	003	6071
21	98-100	23	7/3/2008	11:17	2.0375	23.0045	255-264	003	6071
22	101-103	25	7/3/2008	19:39	2.6853	23.0041	280-298	003	6071
23	104-106	27	8/3/2008	2:58	3.3414	23.0009	240-390	003	6071
24	107-109	29	8/3/2008	12:01	4.0221	23.0036	234-247	003	6071
25	110-112	32	8/3/2008	23:07	5.0331	22.9868	245-273	003	6071
26	113-115	34	9/3/2008	8:06	6.0141	23.0035	220-226	003	6071
27	116-118	36	9/3/2008	17:40	7.0251	22.9963	265-317	003	6071
28	119-121	37	9/3/2008	22:45	7.5224	22.9986	278-335	003	6071
29	122-124	38	10/3/2008	4:05	8.0718	22.9853	384-415	003	6071
30	125-127	39	10/3/2008	9:00	8.5117	23.0006	353-378	003	6071
31	128-130	40	10/3/2008	15:01	9.0101	22.9998	347-408	003	6071
32	135-139	51	13/3/2008	18:50	17.6131	24.2501	400-458	003	6071
33	140-150	51	14/3/2008	0:57	17.6406	24.2814	366-454	003	6071
34	151-158	51	14/3/2008	11:39	17.5974	24.2569	318-418	003	6071
35	159-161	51	14/3/2008	18:15	17.6262	24.2486	380-430	003	6071
36	162-171	51	14/3/2008	20:43	17.6582	24.2497	316-420	003	6071
37	172-180	51	15/3/2008	1:28	17.60	24.25	407-475	003	6071
38	181-188	51	15/3/2008	8:34	17.60	24.25	351-485	003	6071

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2	RV Sonne Fahrtbericht / Cruise Report SO 181 TIPTEQ (from The Incoming Plate to mega Thrust EarthQuakes) 06.12.2004.-26.02.2005. Ed. by Ernst R. Flueh & Ingo Grevemeyer, 2005, 533 pp. In English
3	RV Poseidon Fahrtbericht / Cruise Report POS 316 Carbonate Mounds and Aphotic Corals in the NE-Atlantic 03.08.–17.08.2004. Ed. by Olaf Pfannkuche & Christine Utecht, 2005, 64 pp. In English
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9	RV Sonne Fahrtbericht / Cruise Report SO 191 - New Vents "Puaretanga Hou" 11.01. - 23.03.2007. Ed. by Jörg Bialas, Jens Greinert, Peter Linke, Olaf Pfannkuche, 2007, 190 pp. In English

10 FS ALKOR Fahrtbericht / Cruise Report AL 275 - Geobiological investigations and sampling of aphotic coral reef ecosystems in the NE-Skagerrak, 24.03. - 30.03.2006, Andres Rüggeberg & Armin Form, 39 pp.
In English

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In English

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In English

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In English

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CCHDO Data Processing Notes

Date	Person	Data Type	Action	Summary
2012-03-14	*Bob Key*	BTL	Submitted	to go online
2012-03-14	*Bob Key*	CrsRpt	Submitted	to go online
2012-04-05	*C Berys*	BTL/CrsRpt	Website Updated	Available under 'Files as received'
	File 35A320080223.exc.csv containing bottle data, submitted by Bob Key on 2012-03-14, available under 'Files as received', unprocessed by CCHDO. File Short_Cruise_Report_LAtalante_Leg_4.pdf containing Cruise Documentation, submitted by Bob Key on 2012-03-14, available under 'Files as received', unprocessed by CCHDO.			
2012-05-11	J Kappa	CTD	Submitted	Downloaded from Pangaea
2012-05-14	*Bob Key*	BTL	Submitted	replaces previous file
2012-05-18	J Kappa	CrsRpt	Website Update	New Text version online
	I just added a new text version of the cruise report to the co2clivar/atlantic/a16/a16c_35A320080223/ directory. It will appear online following the next update script run.			
2012-05-22	J Kappa	CrsRpt	Website Update	New PDF version online
	I just added a new PDF version of the cruise report to the co2clivar/atlantic/a16/a16c_35A320080223/ directory. It will appear online following the next update script run.			